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THE JOURNAL OF PROSTHETIC DENTISTRY

VOLUME 11 MAY-JUNE, 1961 NUMBER 3

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REMOVABLE PARTIAL DENTURES
FIXED PARTIAL DENTURES
OPERATIVE DENTISTRY

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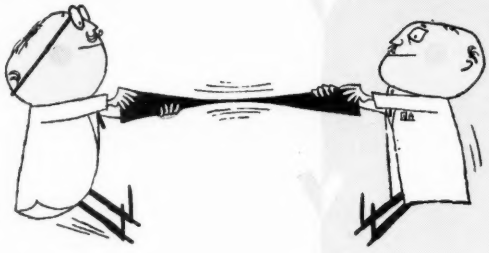

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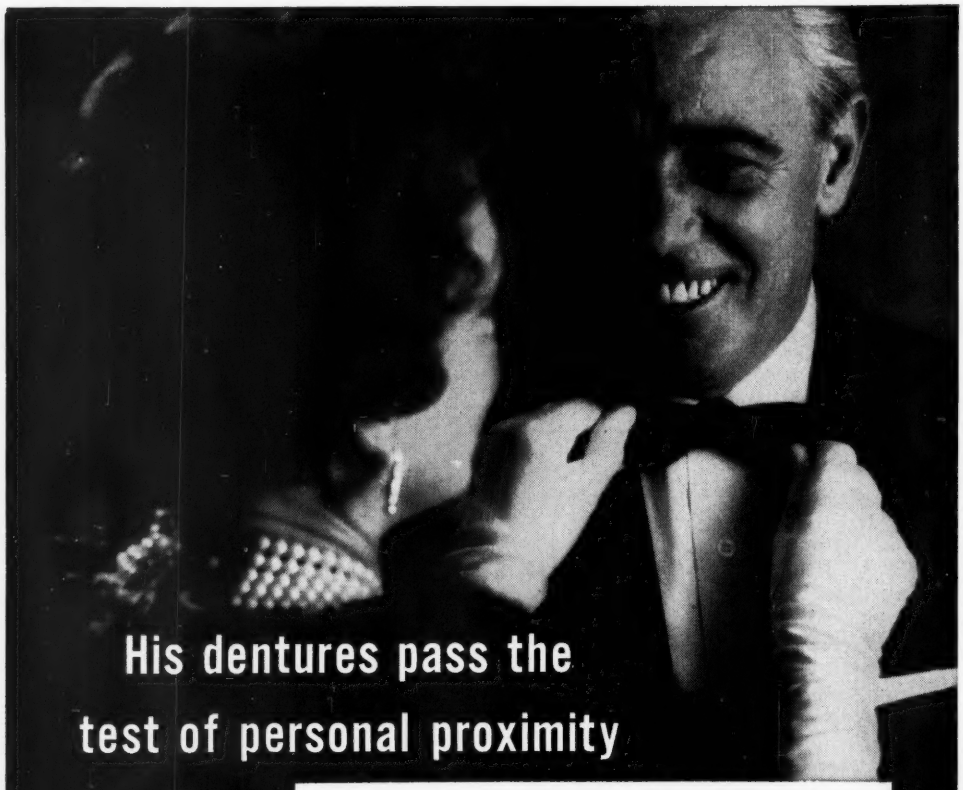

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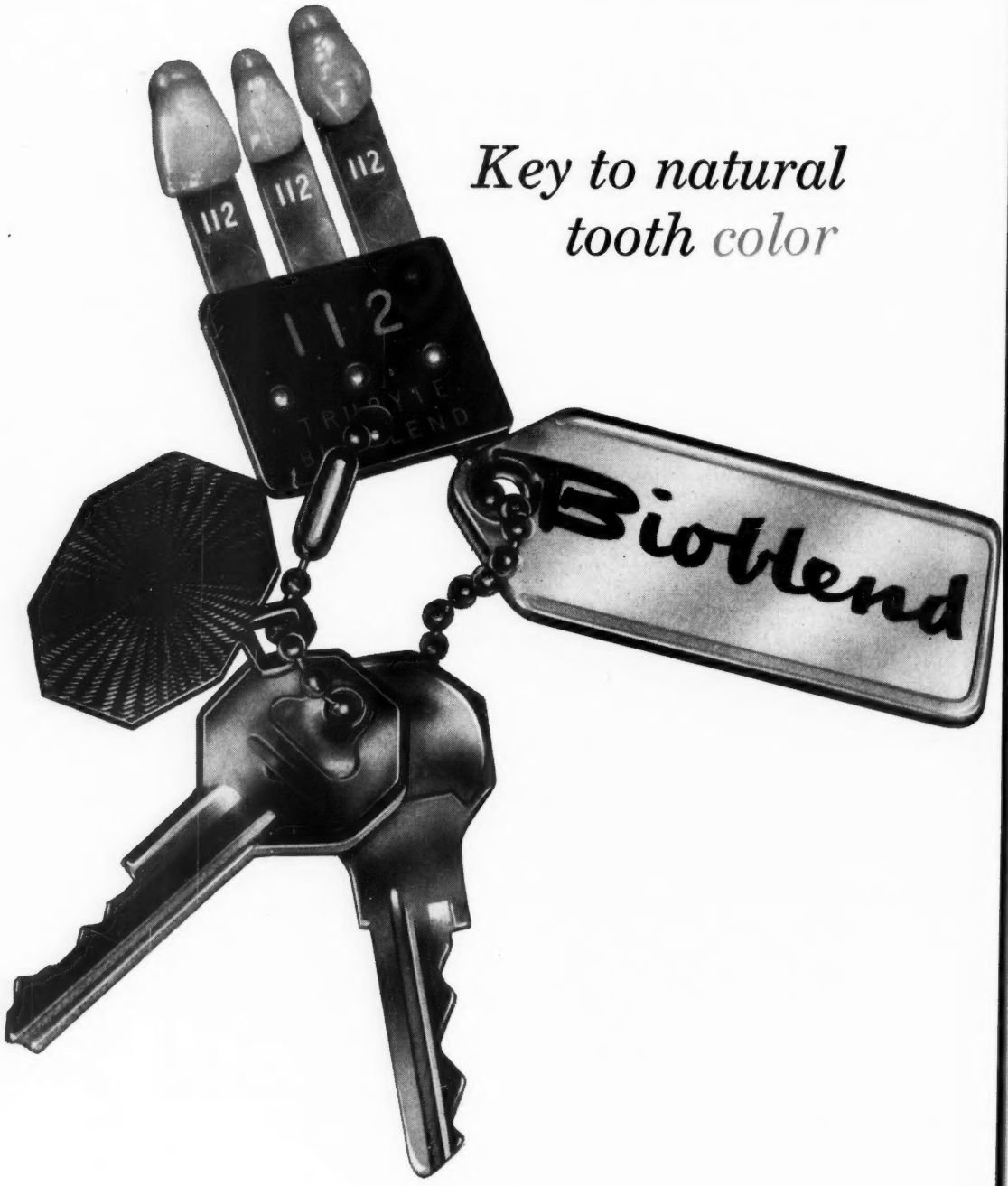

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THE JOURNAL OF
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THROUGH THE EYES OF THE EDITOR

Stanley J. Behrman suggests several procedures which may be used to improve the oral conditions for wearing dentures, and he suggests that these procedures be studied further in order that their value may be evaluated. In these efforts, complete cooperation between the prosthodontist and oral surgeon is essential. Some of the procedures are rather complicated and must be thoroughly understood before they are attempted. The production of transverse grooves across the lower residual ridge is an attempt to overcome one of the major difficulties in denture wearing. When the ridges diverge anteriorly, the dentures tend to slide forward. It will be interesting to see if this procedure will be adequate to overcome this tendency.

Harold H. Blank compares the effectiveness of various materials for making impressions for immediate dentures and describes his impression technique. He makes an acrylic resin tray over a cast from a preliminary impression. By this means, he can control the irreversible hydrocolloid impression material so that the tissues around the border are not displaced.

Theodore L. Stein suggests the construction of a temporary fixed restoration for all but two teeth before an immediate denture is made. The technique reduces the amount of trauma at the time of the insertion of the denture and allows most of the postinsertion bone change to occur before the impressions are made.

Remo Modica suggests a technique for locating the opening axis of the mandible by means of cephalometrics and for transferring this record to the articulator. An allowance must be made for the enlargement of the image on the roentgenogram, but the method offers the opportunity to make a correlation of the occlusal plane with cranial landmarks. This should prove to be a valuable means for further study.

Lawrence Wiland lists eight basic factors which are involved when traumatic occlusion exists. These, and his analysis of the direction of resultant forces when inclined planes contact, should assist in the techniques of developing occlusal harmony.

G. Dal Pont describes the use of his balancing device. It is placed in the lower first molar position and provides balancing contacts in eccentric positions. It could be effective in this function, but the problem of keeping it clean would be a disadvantage. The device has possibilities for use in unusual situations, such as in some surgical prostheses.

Joseph S. Landa points out some causes of pain and numbness under dentures in the final article in his series on trouble shooting in complete denture prosthesis. This series of articles has given a complete analysis of the causes and treatments for all kinds of complaints and difficulties pertinent to wearing dentures.

Carl O. Boucher has taken excerpts from many articles out of context to show that individual phases or steps in different techniques should not be criticized except in relation to *all of the other steps* in the technique being discussed.

J. F. Johnston discusses the preparation of mouths for partial dentures. He lists the objectives of mouth preparation and describes various types of preparations which can accomplish the objectives. This phase of partial denture construction probably has more effect upon the results of prosthetic service than the actual fabrication of the restorations.

Gilbert P. Smith discusses the objectives of fixed partial dentures and the factors to be considered when planning them. He relates the specifications for each of the components of fixed restorations to the objectives of the finished restoration. He indicates areas where compromise is necessary or permissible in certain situations, but these compromises may be made only in the interest of the best total result.

Harvey Stallard and Charles E. Stuart discuss the occlusion of natural teeth and recommend that these occlusions should not be balanced in the same manner as artificial teeth. They place their emphasis on establishing cuspal inclinations in harmony with the "cyclic" chewing motions. They observe damage resulting from teeth that are too flat as well as from those that guide the mandibular closures. It seems that excessive balancing contacts can cause temporomandibular joint disturbances with natural teeth and denture failures with artificial teeth. The neuromuscular system must be respected, and the occlusion must be developed to harmonize with it. Their arguments seem to be logical when applied to natural teeth.

Anthony La Forgia discusses the retraction of gingival tissue before impressions for fixed prostheses are made. The proper choice of technique and material for each specific situation is essential. He describes an orderly technique for the retraction of tissue.

Edward G. Kaufman, David H. Coelho, and Laurence Colin report their studies of variables which affect the retention of gold castings. Their results suggest modifications that can be made in the preparation of teeth which are important to the requirements of specific restorations. The fact that restorations do not seat completely (because of the cement) indicates that further study of this problem is needed.

Yehia Refai Mohammed, Grant Van Huysen, and Drexell A. Boyd report their research on the protection of dental pulps. They found that microscopic pulp exposures occurred in deep cavities and recommend the lining of all deep cavities with a calcium hydroxide base before restorations are placed. Some of the other materials used for this purpose caused damage to the pulp in deep cavities.

James D. Harrison reports his studies of the effects of different retraction materials and techniques on the gingival tissues. He found considerable variation in the damage done by the various materials. On the basis of his results, string saturated with zinc chloride is not recommended.

George R. App reports his studies of the irritation produced by three filling materials. The results confirm previous findings that while silicate and amalgam produce irritation, gold does not. He found that the damage during the preparation of the cavity is repaired within 30 days. This aspect of the problem needs further study.

Zack Kasloff reports his tests of variables in casting techniques and concludes that complicated techniques are not necessary for the production of clinically acceptable castings. It should be noted that other tests are to be made and that careful execution of the procedures is essential.

John C. Bartels discusses the use of porcelain in operative dentistry and describes his techniques for its use in restoring teeth that have major or complicated defects. His methods of reinforcement of porcelain restorations appear to be effective. Many of the problems described could not be solved as well with the use of any other material.

Ralph W. Phillips and his committee report their evaluation of the current research in all phases of dental practice. The amount of research being done is a credit to the dental profession. The results of dental research will contribute to the effectiveness of the methods of prevention and treatment of dental disease.

Judson C. Hickey, Benjamin H. Williams, and Julian B. Woelfel report the results of

their tests by two methods of the stability of mandibular rest position. Cephalometric and electromyographic methods were checked against each other, and the methods showed similar results. Variations were noted in some subjects, but most showed constancy of the position.

Gerald T. Charbeneau tested the effectiveness of supersonic vibrations as an aid to cleaning dental instruments, appliances, and restorations. He recommends specific solutions and vibration frequencies for the most effective cleaning of different items.

S. B. McDonald discusses the various aspects of preparation for making oral presentations to audiences of dentists. Good lectures on dentistry do not just happen. He makes a number of suggestions which should be helpful even to experienced speakers.

—Carl O. Boucher

COMPLETE DENTURES

SURGICAL PREPARATION OF EDENTULOUS RIDGES FOR COMPLETE DENTURES

STANLEY J. BEHRMAN, B.A., D.D.S.*
New York, N. Y.

AN ESTIMATED 21,600,000 people in this country are completely edentulous. This number represents almost 30 per cent of all persons over 35 years of age. Fortunately, dentures that are functional, comfortable, esthetic, and secure can be constructed for most of these patients.[1] Concern must be directed toward that group of patients whose edentulous ridges present irksome, onerous, and exacting problems.

THE SCHIZOIDONTIST, THE PARANOIDONTIST, THE PERIODONTIST

Problem mouths confront the prosthodontist when patients become edentulous after treatment by the schizoidontist, the paranoidontist, or the periodontist.

The "schizoidontist" is the dentist with split mental processes concerning the future of each tooth. On the one hand he would like to save each tooth, but on the other he is doubtful usually because of his own inadequacies. His credo is, "When in doubt, take it out." Unfortunately, he is almost always in doubt. This is the dentist who removes a tooth or two at a time, leaving the patient edentulous but with vast undercuts of the residual alveolar ridge, bulging irregularities, tuberosities, and projections. This patient requires alveolotomy or alveoloplasty by an oral surgeon.

The "paranoidontist" is the dentist to whom every tooth is suspicious. Every tooth is a threat and therefore must be removed. The paranoidontist attacks not only the teeth but the contiguous bone and soft tissue. He trims, chops, scrapes, and hacks. "Cleaning up the mouth," he says, as he leaves the patient with a smooth, scrubbed, overly fashioned residual alveolar ridge which rapidly resorbs into nothingness. The patient, unable to wear dentures because he has been subjected to excessive surgical procedures, is often rapidly "certified" as neurotic

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Read before the Greater New York Academy of Prosthodontics, New York, N. Y., and in part before the American Denture Society, Chicago, Ill.

*Assistant Professor of Clinical Surgery (Dent.), Cornell University Medical College, and Associate Attending Oral Surgeon, The New York Hospital.

or psychotic. The utmost surgical, prosthetic, and psychologic skill must be brought to bear to help this patient.

The periodontist does his utmost to preserve the usefulness of each tooth. Unfortunately, when the periodontist condemns a tooth, most, if not all, of the supporting alveolar bone has been lost. The patient, the recipient of the most judicious attention, now is left edentulous with little or no residual alveolar ridge. His predicament is the result of the "physiologic" resorption of bone attributed to a mysterious "bone factor" or x factor. When designing surgical procedures for this patient, the same dynamism which caused the alveolar bone to disappear may still be at work, and the edentulous mandible may undergo changes of contour and configuration.

ORAL SURGEON–PROSTHODONTIST RELATIONSHIP

All surgical correction of the edentulous mouth prior to the reception of complete dentures must be done under the direction of the prosthodontist. He is the architect and must indicate what he would like to have done. The oral surgeon is the engineer and must devise the methods and carry out procedures to produce the end results indicated by the architect. A good oral surgeon must have substantial flexibility in concept and ability. He must understand that while one prosthodontist prefers a smooth, tapered alveolar ridge, another desires bulges and protuberances which are without undercuts, and still another may prefer to retain substantial undercuts unilaterally. There must, of course, be some degree of receptiveness on the part of the prosthodontist. By an interchange of ideas, the patient will be served best.

Both the oral surgeon and prosthodontist must remember that surgical intervention should be kept to a minimum. Any surgical procedure, no matter how minimal, produces bone resorption. Stanton[2] performed an alveolectomy on a mandible that had been edentulous for 21 years. Thin cortical bone and underlying cancellous bone were removed in the anterior region. Dense cortical bone, "hard as a rock," was altered in the posterior region. A direct bone impression was made and a metal casting constructed. Two and one-half months later the bone was denuded, another impression was made, and a new cast was poured. The original casting, which fit accurately at the time of operation, now had "no stability at all." Significantly, resorption occurred even of the densest cortical bone. Stanton noted that "a mere reflection of mucoperiosteum is sufficient to produce resorption in some cases." His study also indicates that this hastened resorption occurs over a period of 3½ to 6 months. We must anticipate such changes after any surgical procedure.

POSTSCHIZOIDONTAL THERAPY

Maintenance of the height and contour of the alveolar ridge should be the prime concern whenever a tooth is removed. After all, "the making of a satisfactory artificial denture begins with the extraction of the teeth."[3] Careful handling of the soft tissue, conservative, planned, and delineated removal of bone, and, wherever possible, operation on the tooth rather than on the alveolar bone should

be practiced. Studies have indicated that the use of an absorbable gelatin sponge is effective in the maintenance of ridge contour after dental surgical correction.[4] The proper use of this material should be routine.

The care of the patient after the treatment of the schizoidontist is carried out best by three practices: (1) the prosthodontist should indicate the design of the ridge, (2) the bone removal should be kept to a minimum, and (3) the oral surgeon must handle the soft tissue discreetly, trying never to retract the mucoperiosteum to the mucobuccal fold and being careful not to lose ridge height while correcting ridge contour.

POSTPARANOIDONTAL AND POSTPERIODONTAL THERAPY

Particular attention should be devoted to procedures which can be applied to the edentulous mouth following treatment by the paranoidontist. Anatomically, there is little or no alveolar ridge. The borders of the dentures are limited by the conspicuous attachment of certain muscles[5] and the presence of fibrous tissue bands. It is common to find no mucolabial fold or vestibule, enormously enlarged or hypertrophied sublingual glands, and elimination of the retromylohyoid space when the tongue is thrust forward.[6]

Several procedures have been developed or are under development toward the solution of the problems presented by these edentulous mouths: (1) creation of a deep mucolabial sulcus, (2) maintenance of the retromylohyoid space, (3) removal of hypertrophied sublingual glands, (4) creation of transverse ridges to improve denture stability, and (5) two implant techniques. All of these procedures have been either devised at the specific request of prosthodontists or stimulated by an appreciation of the problems facing prosthodontists.

CREATION OF A DEEP MUCOLABIAL SULCUS

None of the materials which have been added to increase the height of the residual alveolar ridge have proved successful. Neither inert materials,[4,7] grafts of aorta, nor cartilage or bone have withstood the stresses of mastication for any length of time.[8]

Fortunately, certain procedures seemingly increase the height of the ridge by deepening the sulci. A deeper mucolabial sulcus can be obtained only by freeing muscle and connective tissue attachments from the mandible.

The simplest technique would seem to be to pass a knife through the sulcus to the desired depth, place an elongated denture into the space created, and wait for epithelization to occur. However, a fundamental principle of surgery is that raw surfaces on soft tissues contract substantially during healing. The healing also is likely to produce dense fibrous scarring. This means that as the raw wound produced with this technique healed, it would contract and reduce the depth of the new sulcus. Also, this technique leaves two large, raw, uncomfortable surfaces to epithelize.

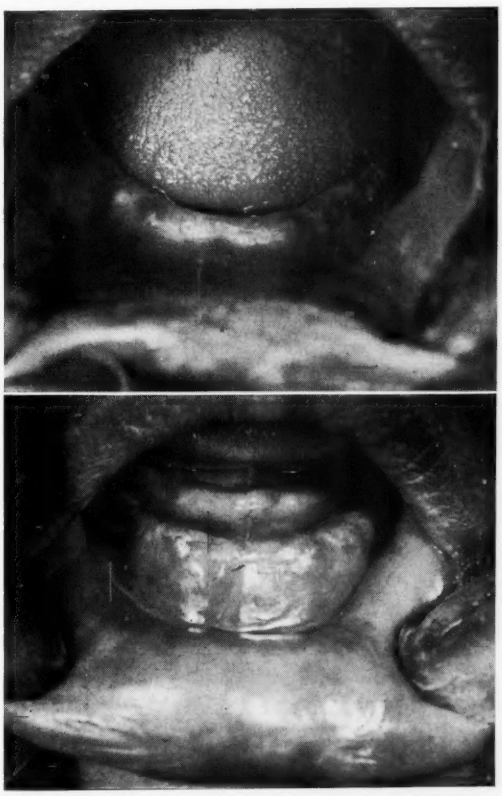
A somewhat similar technique involves the stripping of periosteum and soft tissues from the ridge to the desired depth and placing an elongated denture over the denuded ridge.[9] While the periosteum is used to cover the raw labial surface,

the entire residual alveolar ridge is exposed. How long it takes bone to cover with granulation and the pain associated with denuded bone are well known.

Another technique involves incision of the shallow sulcus and undermining of the mucosa of the lip. The sulcus is deepened, and the mucosa is brought to the depth of the sulcus. The mucosa is held in position by suturing through to the skin.[10] The sulcus is deepened by freeing the connective tissue and muscle attachments from the periosteum, and the periosteum is left to granulate over. Two disadvantages occur with this technique. The first is that scarring occurs in the precise depth of the mucolabial sulcus, leaving a dense fibrous band. This does not provide the flexible mucolabial fold desired by the prosthodontist for a good border seal. The second is that the raw surface of the periosteum remains quite uncomfortable until it is completely epithelized.

Technique of Kazanjian.—A significant technique suggested for the extension of the mucolabial sulcus is that developed by Kazanjian.[11] A horizontal incision is made on the inner surface of the lip approximately 1.5 cm. from the alveolar bone. The mucosa is dissected free as far as the periosteum. The muscles and connective tissue are freed from the periosteum to the new depth of the ridge. The mucosal

A.



B.

Fig. 1.—A deep mucolabial sulcus is created. *A,* Preoperative appearance. *B,* The deep mucolabial sulcus formed by surgical procedures.

flap is brought down and sutured to cover the newly exposed periosteum. The remaining part of the mucosa of the lip is undermined, brought to the depth of the new mucolabial sulcus, and sutured in position covering the raw lip surface. Sutures are passed from this point to the surface of the skin where they are sewed around a roll of gauze or rubber tube. There are no raw surfaces to granulate with this technique. However, scarring does occur in the depth of the mucolabial sulcus.

An advancement of this technique is presented which eliminates the use of sutures to the skin and moves the scar line from the depth of the mucolabial sulcus farther onto the lip. This procedure allows flexibility in the depth of the sulcus, permitting a better border seal (Fig. 1).

Modified Kazanjian Technique.—The lip is held forward and an estimate is made of the amount of mucosa which will be necessary to cover the exposed periosteum, extend to the depth of the new mucolabial sulcus, and extend upward onto the raw lip surface. A semilunar incision is made, with care to note the mental neurovascular bundles.

The mucosa thus outlined is dissected to its attachment to the periosteum. This dissection can be faciliated by "balooning" of the tissues with local anesthesia.

The muscle attachments (mentalis and some of the incisivus labii inferiorus) and connective tissue are carefully freed from the periosteum so it will not be torn. The dissection is carried down to the desired depth of the new mucolabial sulcus.

The previously freed mucosal flap is brought over the denuded periosteum and sutured with fine gut to the depth of the mucolabial sulcus. Mattress sutures that extend well into the periosteum are used. A small "apron" of mucosa approximately 3 to 4 mm. in width is left to extend onto the raw lip surface. The remaining portion of the mucosa of the lip is undermined.

The margin of the newly undermined lip mucosa is brought to the edge of the apron and sutured both to the apron and to the submucosal tissue. Scarring, when it occurs during healing, will be along this line and not in the depth of the mucolabial sulcus.

Self-curing acrylic resin is added to the patient's denture, which is placed in the mouth to maintain the depth of the new mucolabial sulcus. If there is no denture, a previously constructed splint is utilized. A head-chin bandage is kept in place for 24 to 48 hours.

This technique provides (1) good depth of the mucolabial sulcus, which is maintained, (2) no scarring in the depth of the mucolabial sulcus, (3) no raw surfaces, and (4) no through and through sutures in the skin. Similar procedures can be utilized to extend the mucolingual sulcus in the anterior region.

MAINTENANCE OF THE RETROMYLOHYOID SPACE

The retromylohyoid space (lingual to the retromolar pad) often is eliminated by a forward or sideward thrust of the patient's tongue.[6] Two surgical techniques have been suggested to overcome this problem. The first,[12] similar to the previously mentioned techniques for extension of the mucolabial sulcus, has the disadvantages of raw periosteal surfaces and skin sutures.

The second technique[13] is more applicable than the first. An incision is made along the crest of the ridge to the bone, and the mucoperiosteum is elevated. The mylohyoid ridge is trimmed off. The periosteum is freed to the lower border of the mandible. The original incision is closed, and a rubber catheter is placed deep in the mucolingual sulcus and sutured through to the skin. This catheter is kept in place for 1 week to produce fixation to this new depth. The depth of the new mucolingual sulcus will be maintained in some patients if there has been enough scarifaction of the tissue. In many other patients, the tissue resumes normal flexibility and elasticity, and, although there is the advantage of a rounded mylohyoid shelf, the retromylohyoid space is lost when the tongue is extended.

Fig. 2.—Surgically created "alveolar locks" minimize tipping and side to side shifting of a denture.

We are conducting animal experiments with a variety of sclerosing solutions. The solutions are injected into the flexible and movable tissue in the retromylohyoid space. The amount of tissue rigidity obtained is being evaluated. It is hoped that a simple technique will be developed which will bind down the tissues, yet not interfere with their physiologic state or ability to withstand denture-bearing stresses.

REMOVAL OF HYPERTROPHIED SUBLINGUAL GLANDS

Extremely large, hypertrophied sublingual salivary glands sometimes present a substantial problem to the prosthodontist.[6] These glands overfill the mylohyoid or sublingual space and contribute to denture displacement. The sublingual glands are the smallest and least productive of the three pairs of salivary glands emptying into the mouth and contribute about one-tenth of the total salivary secretion. In addition, lubrication of the oral cavity is enhanced by myriad secretory glands in the mucosa of the cheeks, lips, and palate.

Some prosthodontists* have requested that these enlarged glands be removed to eliminate their obliteration of the sublingual space. The glands can be excised

*I. E. Klein: Personal communication.

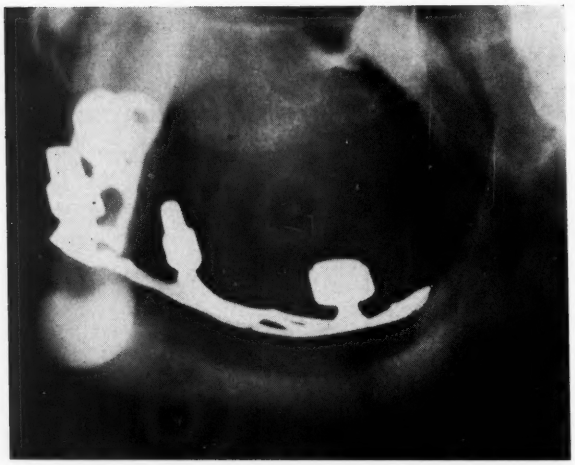


Fig. 3.—Bone resorption has occurred beneath a subperiosteal implant framework 5 years after insertion.

under local anesthesia as an office procedure. Wharton's duct, which extends from the submaxillary gland, and the lingual nerve that crosses from the medial portion of the mandible to the tongue must not be disturbed. The tissues must be handled delicately, the dissection must be carried out with care, and all vessels must be meticulously tied off. Otherwise, substantial edema may develop in this region, with considerable patient discomfort. The glands should be removed from one side at a time.

TRANSVERSE GROOVES ACROSS THE ALVEOLAR RIDGE

Sometimes, when there is a sufficient residual alveolar ridge and retention is not a problem, there is a problem of side to side shifting and of tipping of the denture.

Klein* has suggested the creation of grooves through the ridge in the first molar region. These grooves almost lock the denture in place, preventing tipping and side to side shifting and enhancing retention (Fig. 2). An incision is made along the crest of the ridge through the mucoperiosteum, which is carefully reflected and held with retracting sutures. A groove, approximately 5 mm. wide, is created by removal of alveolar bone from the buccal to the lingual surface of the ridge. The groove is carried approximately 2 mm. deeper than the mucobuccal sulcus. The mucoperiosteal flaps are incised in "barn door" fashion by making a vertical incision in the midline of the groove and horizontal incisions to the edges of the groove. The "barn doors" are closed to protect the proximal bony surfaces. Self-curing acrylic resin extensions are added to the patient's denture, and the denture is placed in the mouth. Follow-up of almost 3 years has shown no significant increase in bone resorption in the region of the operation, and the patients have reported substantial improvement in denture function.

*I. E. Klein: Personal communication.

IMPLANT TECHNIQUES

Subperiosteal Implants.—The technique which has received the most attention in its attempt to overcome the problems of the ridgeless, edentulous mouth has been the subperiosteal or denture implant.[14] The mucoperiosteum is reflected and a direct impression is made of the bone. A framework of tissue-tolerated metal is placed on the bone and covered with mucoperiosteum except for four posts which protrude through the soft tissue into the mouth. A denture is placed onto these four posts.

Long-term evaluation of this technique has shown that, in many instances, the bone of the mandible is unable to withstand the stresses of mastication transmitted directly by the dental implants. Consequently, resorption of bone resulting from stress occurs.[15] Once resorption starts, the subperiosteal implant is no longer absolutely immobile, and it is a well-established principle of implantation that stress-bearing implants must be immobile.[16] The least mobility rapidly increases the resorption of bone. This in turn further increases mobility, and the vicious cycle revolves progressively faster (Fig. 3). This expensive, laborious technique is indicated for select patients and must be limited to the highly skilled team of prosthodontist, oral surgeon, and laboratory technician.[17]

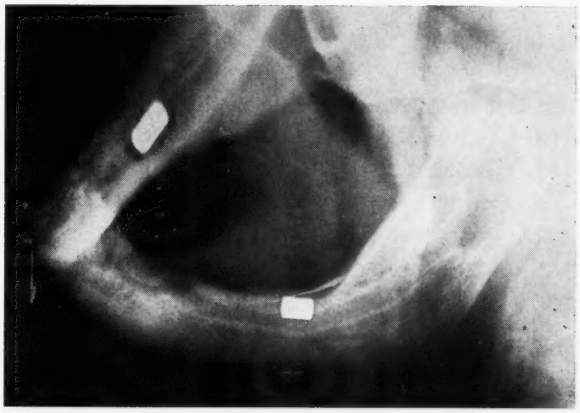


Fig. 4.—An excellent quality of bone was observed around magnetic implants 7 years after insertion.

Magnetic Implants.—Another technique which observes all principles of implantation is the magnetic implant.[1,18] Tiny, powerful, tissue-tolerated magnets* (¼ by ⅛ by ⅛ inch in size) are placed in vaults *in the bone* and covered completely by mucoperiosteum. Similar magnets are placed in a complete denture, and the attraction between the magnets in the jaw and the magnets in the denture helps to hold the denture in place.

The surgical technique is simple, requiring approximately 20 minutes for each side. The mucoperiosteum is incised sharply from the molar to the biscuspid region. The mucosa and periosteum are carefully reflected and retracted with four retracting sutures in each flap. By means of either a dental engine or an air turbine

*Behrman Magnetic Implant, Ethical Specialties, Inc., Bloomfield, N. J.

high speed drill, a vault is prepared in the mandible with the use of round and fissure burs. The broadest, flattest part of the jaw is selected (usually the first or second molar area). The vault measures approximately ¼ inch in length, ⅛ inch in width, and ⅛ inch in depth. The denture magnet is used as a guide to determine the vault depth with which the top of the magnet will be flush with the level of the bone. A small rectangle of mesh comes attached to the implant magnet in order that it may be suspended in position in the vault. The mesh is trimmed so that several millimeters of it overlaps the bony margins of the vault.[5] The muco-periosteum is closed with sutures.

One month after surgical operation, complete dentures are made with the posterior part of the buccal flanges constructed of clear acrylic resin. Magnets are placed in these dentures by a very simple method. The lower denture is removed from the mouth, and a magnet is placed on the posterior part of the lower alveolar ridge. The magnet will be attracted to the magnet in the jaw and will always assume the correct position. The mesial and distal aspects of the magnet are marked on the buccal mucosa, the magnet is removed, the denture is seated, and the markings are transferred to the denture. A window, larger than the indicated markings, is cut completely through the buccal flange of the denture. The border is left intact.

The denture is placed in the mouth, and the magnet is placed in the window making certain that it does not touch any part of the denture-base material. When this magnet is correctly seated over the magnet in the mandible and is completely free of contact with the denture, self-curing polymer is placed in the window. The patient is instructed to close the teeth in centric occlusion, and several drops of monomer are added. The patient holds the teeth in centric occlusion until the acrylic resin has cured. The denture is removed from the mouth, and defects in the resin on the tissue surface are corrected with self-curing resin by the brush technique. Upon completion, the undersurface of the magnet is an integral part of the tissue surface of the denture.

Histologic, clinical, and roentgenographic follow-up over an 8 year period has indicated (1) no adverse microscopic tissue reaction, (2) no gross tissue reaction, and (3) no roentgenographic evidence of intolerance or increased bone resorption. The magnets are so well tolerated by the tissue that bone grows around the rounded edges of the implants. The bone had to be removed with chisels and burs to dislodge several magnets for histologic study. This simple, inexpensive, and effective technique which observes every principle of implantation[19] appears to be withstanding the test of time (Fig. 4).

CONCLUSIONS

This article has indicated several points. First, the oral surgeon has a deep appreciation of the problems facing the prosthodontist. Second, a number of surgical procedures afford substantial assistance in the treatment of the edentulous mouth. Third, research and investigation are necessary, for the problems are far from solved. Fourth, critical evaluation of present procedures must continue, and attempts must be made to devise new procedures to better treat the people who trust and depend upon the skills of dentistry.

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IMPRESSION MATERIALS FOR MAXILLARY IMMEDIATE DENTURES

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BEFORE THE INTRODUCTION of reversible hydrocolloid in 1925, impressions for immediate dentures were made with materials which required a sectional technique. Some of the sectional techniques are: (1) complete plaster impression, (2) sectional modeling compound technique,[1] (3) combination of modeling compound and plaster sectional impressions,[2] (4) sectional impression technique employing modeling compound and zinc oxide–eugenol paste,[3] and (5) sectional impression of hydrocolloid and modeling compound.[4]

Since 1939, one piece, border-molded impressions have been made with an irreversible hydrocolloid (alginate). Irreversible hydrocolloid has approximately the same accuracy as reversible hydrocolloid when used in a specially made tray[5] and is preferable to reversible hydrocolloid because of the ease of handling.

In 1952, polysulfide rubber† was introduced as an impression material. Since then, polysulfide rubber and silicones have attained some prominence as impression materials for immediate dentures.[6]

This article evaluates impression materials for immediate dentures and describes a procedure for making the preliminary and final impressions for maxillary immediate dentures.

COMPARATIVE VALUES OF IMPRESSION MATERIALS

The advantages of a one piece impression over a sectional impression are increased accuracy, economy of time, and simplification of technique.

Irreversible Hydrocolloid.—The advantages of irreversible hydrocolloid are that (1) it produces a one piece impression, (2) it is easy to manipulate, (3) it can be removed from the mouth without distortion, (4) it flows and does not trap air, (5) it requires a minimum of equipment, and (6) it provides exact duplication. Some of the disadvantages are that (1) the cast must be poured within 30 minutes, (2) it must be stored in a 100 per cent moisture humidor, (3) it is fragile, (4) wax does not adhere to it readily for boxing purposes, and (5) it must be separated from the cast within 1 hour after pouring.

Reversible Hydrocolloid.—Reversible hydrocolloid has most of the advantages and all of the disadvantages of irreversible hydrocolloid. Additional disadvantages of reversible hydrocolloid are that (1) it must be heat treated and kept at a spe-

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†Thiokol.

Fig. 1.—The rim lock is beaded with soft, red utility wax, and green stick modeling compound is added in the palatal part.

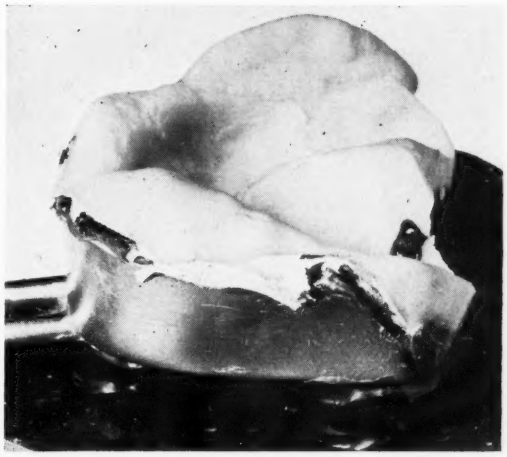

Fig. 2.—The preliminary impression is on the paddle and is leveled with wax.

cific temperature for use, (2) it requires more extensive armamentarium and preparation, and (3) it requires special water-cooled trays which are difficult to border mold without distorting the surrounding tissues.

Polysulfide Rubber and Silicones.—The advantages of these two materials are that (1) they are elastic and very tough, (2) they provide comparable duplication to hydrocolloid, and (3) the casts need not be poured immediately, but within the day in which the impressions are made.[7]

The disadvantages of polysulfide rubber and silicones are that (1) they contain internal voids, especially in deep undercuts, and (2) they will not tear between

the teeth when the impression is removed from the mouth. Therefore, there is a tendency for the material to pull away from the tray and cause distortion.

PRELIMINARY IMPRESSION TECHNIQUE

A rim lock tray which covers the denture-supporting tissues and the remaining anterior teeth is selected. The mouth is checked to locate any distortion of the tissue which is caused by overextension of the tray. If the vault of the palate is high, green stick modeling compound is molded onto the palatal part of the tray. The flanges (borders) of the tray are corrected with soft, red utility wax (Fig. 1). The bulk of the rim lock tray will cause distortion of the cheeks; therefore, a preliminary impression is made first.

Fig. 3.—The impression prepared by the paddle-grip wax boxing technique is ready for pouring in artificial stone.

The tissues are dried with gauze. The irreversible hydrocolloid is mixed according to the manufacturer's directions, placed in the tray, and formed with a wet finger to remove all irregularities. The tray is placed in the mouth; after 5 minutes, the impression is removed with a snap in a straight line to break the seal and placed in a 100 per cent moisture humidor.

Irreversible hydrocolloids are delicately balanced in their composition in relation to water content. After the impression gels, the cast should be poured within 30 minutes to prevent distortion and must be kept at 100 per cent humidity while the stone is setting. The impression should not be placed in water at any time.

Fig. 4.—A custom-made acrylic resin tray is shortened to permit border molding in green stick modeling compound.

PADDLE–GRIP WAX TECHNIQUE FOR BOXING

The rim lock tray which has been beaded with wax along its entire border is placed on a Vibra paddle. The tray is made level with balls of wax and sealed on the paddle with wax (Fig. 2). A strip of boxing grip wax is attached between the beading wax and the paddle, then a strip of boxing wax is sealed against the black wax strip. The lower edge of the strip of boxing wax is securely sealed to the wax on the paddle (Fig. 3).

A thick mix of artificial stone is flowed into the impression with a strong vibrator. The resultant cast is permitted to harden in the humidor for a minimum of 30 minutes, but no longer than 1 hour or the cast will be flaky. After separation, a second cast is poured to be used as a diagnostic cast.

Fig. 5.

Fig. 6.

Fig. 5—The acrylic resin tray has been border molded, and the wax stops are in place.
Fig. 6.—Strands of dry cotton fibers are attached to the tray to provide retention for the irreversible hydrocolloid.

FINAL IMPRESSION TECHNIQUE

A final impression is made in a self-curing plastic or a double thickness baseplate tray made on the preliminary cast. The tray is made over a 19 gauge thickness wax spacer after all undercuts in the cast have been blocked out. A doughy mix of self-curing acrylic resin is molded over the wax spacer and trimmed when cured (Fig. 4). The borders of the tray are reduced so they are 3 to 4 mm. short of the reflections.

The tray is border molded with green stick modeling compound or red rim wax if there are deep undercuts. The border is purposely shortened by 1 mm. in the molding procedure by pulling on the cheeks and lips. Holes are made in the tray, with a No. 10 round bur, in the palatal part and over the teeth so that the impression material will adhere to the tray. Two loops of dental floss are passed through the holes in the tray to permit easy removal of the tray after the impression material has gelled.[8]

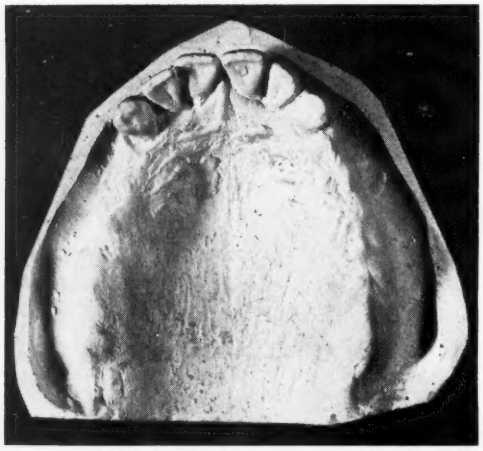

Fig. 7.—The master cast shows all of the detail that is necessary for fabricating the immediate denture.

Soft utility wax stops are placed in the tray so that they correspond to the position of firm tissue. The stops are placed mesial to the position of the second bicuspid and distal to the first molar on both sides, and one is placed posterior to the rugae. The stops raise the tray 2 mm. away from the ridge to allow space for the irreversible hydrocolloid (Fig. 5).

The tissue side of the tray is swabbed with loose cotton that has been dipped in adhesive, and strands of the dry cotton fibers are permitted to adhere to the surface of the tray. The adhesive and cotton aid in the retention of the impression material (Fig. 6).

The tray is loaded with impression material and is seated in the mouth from front to back, with the dentist standing first in front of the patient and then behind him. The patient is seated upright and instructed to breathe through the nose. A

mouth mirror is used to remove excess material that goes too far past the posterior edge of the tray. Then, the patient makes sucking motions with the lips, the dentist molds the cheeks in the tuberosity and buccal regions, and the lip is stretched downward in the region of the upper labial frenum. The patient is asked to bring the tip of the tongue forward to touch the outside of the lower lip and then to the right and left corners of the mouth to mold the impression material in the hamular notches.

After an interval of 5 minutes, one side of the lip is raised and air is blown between the impression and the tissue to help break the seal. The impression is removed with a straight pull on the two loops of dental floss and is examined carefully for defects. Plaster of Paris is sprinkled on the impression to remove the saliva, and the impression is washed off and placed in the humidor for no more than 30 minutes. The boxing of the impression and pouring of the cast are completed using the same technique as described for the preliminary impression (Fig. 7).

Incorrect irreversible hydrocolloid impressions result when (1) too little material is used, (2) spatulation is not adequate, (3) the impression material is not allowed enough time to set, and (4) there is movement of the impression during the gelling period.

SUMMARY AND CONCLUSIONS

1. Irreversible hydrocolloid is the impression material of choice for upper immediate dentures.

2. Irreversible hydrocolloid is a delicately balanced impression material and must be handled according to proved methods.

3. Irreversible hydrocolloid impressions should be boxed before the casts are poured.

4. An impression is made and *not* taken. Therefore, the anatomic and physiologic conditions of the denture-bearing surface must be known by the dentist.

5. A systematic technique of making the impression for an immediate upper denture has been described.

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IMMEDIATE DENTURE PROCEDURE UTILIZING A TEMPORARY FIXED PARTIAL DENTURE

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THE DEVELOPMENT of cold-curing acrylic resin makes practicable a new procedure for the extraction and replacement of teeth by complete or partial dentures. In this procedure, a temporary immediate acrylic resin fixed partial denture is made to preserve the appearance of the patient when all but two teeth in the upper or lower jaw have been removed. The procedure permits postextraction healing of most of the anterior part of the jaw, in addition to the usual healing of the posterior part, before the impression for the immediate denture is made. This article discusses the technique as it applies to immediate complete dentures.

DIAGNOSIS

When an immediate complete denture is to be made, the treatment plan for a temporary immediate fixed partial denture must be carefully determined. The two abutment teeth selected must be nearly parallel, not too loose, not too badly broken down, not too close to each other in location, and not too badly abraded on the incisal surface, which must be ground later. Decisions must be made as to whether the first premolars should be replaced on the temporary restoration by cantilevered pontics, whether the anterior teeth can serve as patterns for the fixed partial denture, and whether the lateral incisors can be used as abutments to supply incisor pontics and cantilevered cuspid pontics to avoid troublesome postextraction shrinkage in the canine region. In most instances, the cuspids serve well as temporary abutment teeth for the four incisor pontics on the temporary fixed restoration.

PROCEDURE

The pattern of the temporary fixed partial denture is established on the diagnostic casts. A layer of wax is added to the buccal and proximal surfaces of the abutment teeth on the diagnostic cast to minimize the grinding of these teeth in the mouth. The other remaining teeth are modified by waxing and cutting to create a good-looking, strong-structured pontic pattern.

An elastic impression is made of the modified cast to serve as a mold for the external surface of the fixed partial denture. Solid pontics are constructed by pouring cold-curing filling resin into the impression. After the incisal shade is poured and the resin has cured, the midcoronal shade is poured. Solid pontics are completed in this manner to compensate for the shrinkage of polymerization. Thin

abutment crowns are attached to the pontics within the impression by painting in the resin with the brush technique. After the resin has set, it is removed from the impression and an extra crown is made for each abutment tooth so that the temporary fixed partial denture procedure need not be completed at one appointment.

Generally, temporary fixed partial dentures are used after healing of the posterior sockets. The abutment teeth are prepared to receive the temporary crowns, and the occluding part is reduced to permit replacement by a durable layer of resin. The axial surfaces of the abutment teeth require little preparation, since the temporary crown can be thickened on the outside by addition of the filling resin.

The abutment crown shells are relined on the prepared teeth with filling resin. The crown is removed before the resin has cured, to facilitate removal of the parts that engage undercuts. The crowns are polished and attached to the abutment teeth with a temporary cement.

At another appointment, the anterior teeth which are to be replaced by the temporary pontics are removed. The temporary crowns are removed from the abutment teeth, and the temporary fixed partial denture is fitted by relining the acrylic resin shell crowns on the temporary restoration.

After the anterior tooth sockets have healed, the complete immediate denture is made. The temporary fixed partial denture is removed while the impression is made, the jaw relations are recorded, and the trial setup is tested. The abutment teeth are extracted when the denture is completed.

ADVANTAGES AND DISADVANTAGES

The advantages of this procedure come from early extraction of certain anterior teeth which allows a large proportion of the jaw to heal before the final impressions are made. Less tissue shrinkage occurs after the denture is placed in the mouth. The anterior teeth can be tested in the trial setup, and the temporary fixed partial denture improves the appearance of some patients during the denture construction period.

The disadvantage of this technique is the extra work involved in making a temporary fixed partial denture. Preparation of the temporary abutment teeth and temporary denture involves pain, time, and expense to the patient. Emergency recementing and repair may be required.

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CAST ORIENTATION BY CEPHALOMETRICS

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CEPHALOMETRIC ROENTGENOLOGY, as proposed for orthodontics, has become a method of research for anthropology and prosthodontics.[1] It is possible to make comparative roentgenologic skull examinations of different subjects and also, because of only slight distortion of the image, to make correct angular and linear measurements. If necessary, the measurements can be corrected by calculating the corresponding coefficient of deformity connected with the roentgenogram.

The measurements for cast orientation on the articulator have been made directly on the patient with instruments that are more or less complicated, such as various types of face-bows. This method has the disadvantage of determining the position of the bony structures only indirectly through the skin landmarks.

The purpose of this article is to describe a cephalometric method for correct orientation of the casts on the articulator.

CEPHALOMETRIC ANALYSIS OF EDENTULOUS JAWS

The best-known view in cephalometrics is the profile roentgenogram. In previous studies,[2] however, axial views of the skull were made to determine the individual intercondylar distance, which can be useful in mounting casts on certain articulators.

MEASURING THE INTERCONDYLAR DISTANCE

Landmarks indicating the position of each condyle were made on the skin by means of small radiopaque balls, and the distance between the landmarks was measured by a spreading caliper. The ratio between the clinical measurement and the corresponding value on the roentgenogram supplied the data for a proportion by which the true distance between the two condyles could be established. Two evaluations were made: (1) the lateral intercondylar distance between the outer margins of the condyles and (2) the central intercondylar distance between the morphologic centers of the condyles, which are a direct continuation of the neck of the condyles and likely to coincide with their functional centers (Fig. 1). The following data were obtained: (1) a lateral intercondylar distance of 109.7 mm. with a standard deviation of 6.16 and (2) a central intercondylar distance of 96.5 mm. with a standard deviation of 6.25.

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DETERMINING THE ANGULAR DEVIATION

With an axial cephalometric roentgenogram, it is possible to measure the angular deviation between the median sagittal axis of the maxillae and the intercondylar axis. These axes are usually considered to be perpendicular to each other for purposes of mounting casts on an articulator.

A wax occlusion rim was accurately adapted to the upper cast. Two small metal markers were placed in the occlusion rim so that one corresponded to the position of the incisive papilla and the other was either midway between the foveae palatinae or at the apex of the posterior nasal spine when it could be identified on the cast (Fig. 2).[3] The rim was placed in the mouth, and an axial cephalogram was

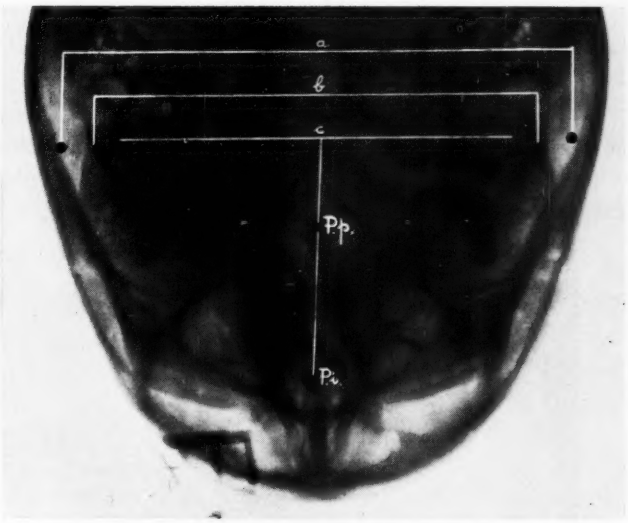


Fig. 1.—A roentgenographic axial view of the skull shows: *(a)* The external intercondylar distance (cutaneous); *(b)* the lateral intercondylar distance; *(c)* the central intercondylar distance; *(P.p.P.i.)* the median sagittal axis of the maxillae.

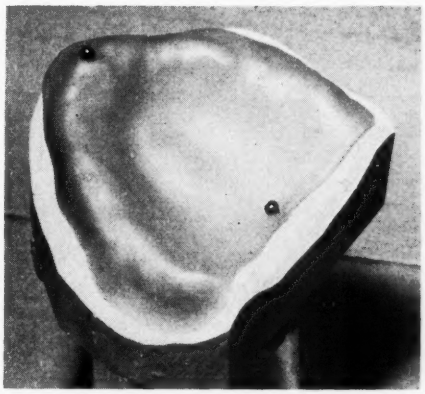


Fig. 2.—Metal landmarks were placed in the occlusion rim for the roentgenologic identification of the incisive papilla and the posterior palatine point.

made. The two landmarks of the maxillae were connected on the film, and the line was extended until it met the intercondylar axis. Then, the angle between the median axis of the maxillae and the intercondylar axis was calculated. The mean deviation of the angle when referred to ninety degrees was two degrees with a standard deviation of 1.4. Moreover, by comparing the point where the two axes cross with the central point of the intercondylar axis, it is also possible to determine the lateral displacement of one jaw over the other.

MATERIALS AND METHODS

Twenty-eight edentulous persons ranging from 40 to 76 years of age were examined; 18 were women and 10 were men. The main cause for the loss of teeth, the duration of the edentulous condition, and the type of former dentures were noted.

A wax occlusion rim was made on the upper cast of each patient. Two radiopaque markers were placed in the corresponding position of the incisive papilla and between the foveae palatinae or at the apex of the posterior nasal spine when recognizable. With the occlusion rim in the mouth, two profile cephalograms were made with the mandible in rest position (one to control the results).

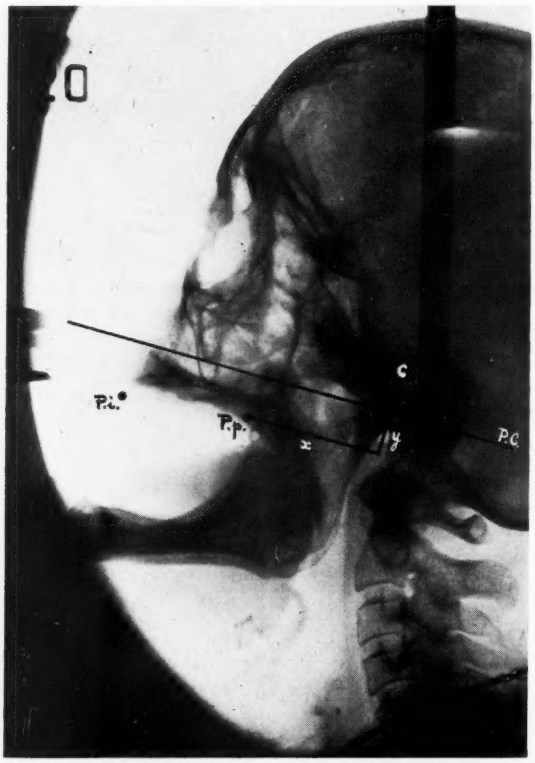
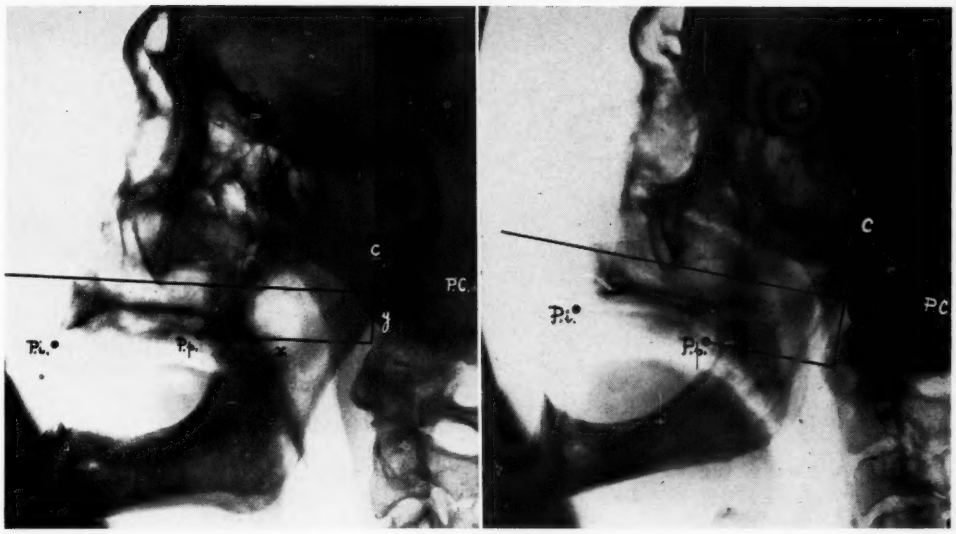


Fig. 3.—A profile cephalometric roentgenogram shows: *(P.C.)* Camper's plane; *(P.i.)* the incisive papilla; *(P.p.)* the posterior palatine point; *(C)* the vertex of the condyle; *(x,y)* the coordinates of *P.p.* with *C* in relation to Camper's plane.



A. *B.*

Fig. 4.—Profile cephalograms. *A*, An extension of coordinate x in maxillary prognathism. *B*, The greater height of coordinate y in mandibular prognathism.

The patient's head was immobilized in a cephalostat (Broadbent type, modified by Weingart) that was rigidly fastened to the wall so that the cranial Frankfort plane was parallel to the floor. The roentgen tube was located 1.8 M. from the central point of the cephalostat and was also rigidly fixed to the wall. The exposure time for each cephalogram was 3 seconds.

MORPHOLOGIC CONSIDERATIONS

Particularly constant in every person was the position of the posterior nasal spine, which is strengthened by two laminae of compact bone that take common origin from it. The posterior palatine point, which is the projection of the posterior nasal spine on the oral mucosa, can easily be identified both on the cast and on the roentgenogram with the help of a marked occlusion rim, and it is used as a landmark. Therefore, the position of this point was determined for eventual practical utilization.

METRIC CONSIDERATIONS

Casts were mounted on an articulator essentially in relation to the position of the artificial condyles. In Fig. 3, therefore, the position of point *P.p.* in the edentulous roentgenogram is determined in relation to the condyle. Point *P.p.* is located on a sagittal plane which for convenience is generally considered median and perpendicular to the intercondylar axis.

The position that point *P.p.* occupies in the sagittal plane in relation to the point where the intercondylar axis crosses the plane can be determined by measuring coordinates x and y relative to a selected conventional line or plane (Fig. 3).

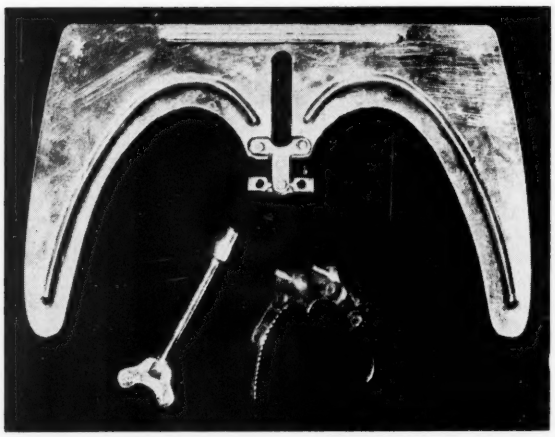


Fig. 5.—The parts of the M.C. device: a registration plane with ball joint, a locking key, and a connecting plate with cogged attachments and pivots.

Fig. 6.—The registration plane of the M.C. device is parallel with the tragus-ala line and with the line passing through the pupils of the eyes.

For practical reasons, the landmark chosen is Camper's plane. Roentgenographically, Camper's plane is the union in a straight line of the base of the anterior nasal spine with the center of the external auditory meatus. The cephalometric roentgenogram permits these calculations since it also is a projection on the sagittal plane.

The results of the determination of the x and y coordinates of the test subjects were (1) a mean value for x of 41.5 mm. with a standard deviation of 4 and (2) a mean value for y of 22 mm. with a standard deviation of 5. The highest values of x correspond generally to maxillary prognathism, while those of y correspond to mandibular prognathism (Fig. 4).

The values reported are not absolute because the coefficient of enlargement which accompanies each cephalometric roentgenogram was not taken into consideration. However, since the measurements were made in the center of the film, the distortion was small.

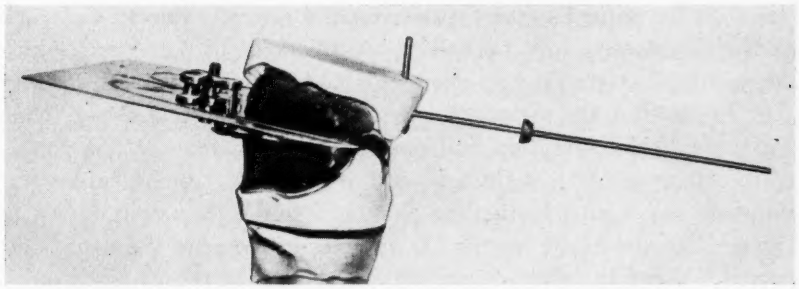


Fig. 7.—A metal rod with a slider is fixed to the upper cast and indicates the posterior extension of the median sagittal axis passing through *P.p.* The rod is parallel to the plane of the M.C. device.

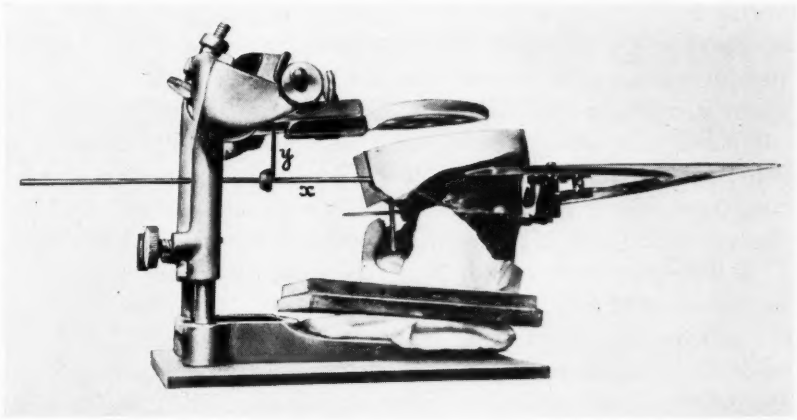


Fig. 8.—The plane of the M.C. device is made parallel to the work bench. The casts are placed in the articulator so that the coordinates of *P.p.* to the intercondylar axis are equal vertically to y and horizontally to x.

CLINICAL PHASE

The clinical phase of the technique is essentially the recording of Camper's plane. The M.C. device (Fig. 5) designed by Modica and Carmagnola[4] is useful for this purpose. The device is a Fox plane that oscillates on a ball joint that can be locked with a key when the desired position is reached. The apparatus is inserted and removed by two vertical pivots placed on a metal platform from which two cogged attachments extend posteriorly.

After the positional relations of the jaws are recorded, the device is placed in the patient's mouth with the cogged attachments fixed into the wax occlusion rims. In this preliminary phase, the M.C. device is oriented approximately so that the middle posterior spine of the metal plate, where the attachments are located, is fixed in the center of the wax occlusion rims. Then, the recording plane is detached from the two pivots of the metal plate, and the occlusion rims are removed so that sticky wax can be added to the metallic arms for reinforcement.

The lines on the patient's face that correspond on each side to Camper's plane are marked with adhesive tape by uniting the midpoint of the tragus with the ala nasi (2 mm. above, according to roentgenographic observations). The occlusion rims are again placed in the mouth, and the recording plane is inserted. The patient is asked to stand, hold his head up, and look straight forward.

The recording plane is adjusted until it becomes parallel on each side to Camper's plane and frontal to the line passing through the pupils of the patient's eyes (Fig. 6). Because of the frequent asymmetry of the eyes, the floor is also used as a reference.[5] When the desired position is reached, the recording plane is locked with the key and slid off from the pivots, and the casts are ready for mounting on the articulator.

LABORATORY PHASE

The casts are placed on the articulator so that point *P.p.* indicated on the cast by the metal marker has a horizontal coordinate equal to x and a vertical coordinate equal to y with regard to the intercondylar axis. Several methods can be used to achieve this result, however only one will be described.

A notch is made in the back of the upper cast so that point *P.p.* can be reached by means of a straight metal rod. The notch must not interfere with the anatomic part of the cast. The rod is attached to the plaster with sticky wax so that starting from point *P.p.* it goes backward in continuity with the middle sagittal axis of the upper cast and in a direction parallel to the plane of the M.C. device (Fig. 7). A slider that moves freely along the metal rod is adjusted at a distance from point *P.p.* equal to x.

The occlusion rims, casts, M.C. device anteriorly, and metal rod posteriorly are placed in the articulator (Fig. 8). Another metal rod with a length equal to y is extended from the midpoint of the intercondylar axis. The casts are oriented so that the lower end of vertical rod y coincides with the point where the slider marks the posterior end of x on the horizontal rod. Sometimes, the recording plane of the M.C. device must be adjusted to be parallel to the plane of the table on which the articulator rests. The middle sagittal axis of the upper cast indicated by the posterior extension of the horizontal rod must be perpendicular to the intercondylar axis. The casts are supported on Plasticine or soft wax until they are adjusted to the correct position.

If the exact deviation of the jaws of each subject (the angle between the median sagittal axis of the maxillae and the intercondylar axis) is reproduced, the casts are adjusted by means of a protractor according to the individual roentgenographic value. In the same way, the lateral eccentricity of the maxillae in regard to the condyles can be reproduced by moving the casts proportionally in the proper direction. The mounting of the casts on the articulator is done in the usual manner.

The roentgenographic method can also be used to determine the individual intercondylar distance for those articulators that permit this adjustment.[6] However, the intercondylar distance does not differ excessively from the 10 cm. distance noted by Bonwill.

SUMMARY

The application of the cephalometric method to the construction of complete dentures has been described. This method eliminates some of the disadvantages of instrumental registration such as approximation, patient inhibition, and subjective considerations.

The graphic and instrumental registrations necessary to correctly orient casts on the articulator with the use of cephalometric roentgenograms were described.

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INCLINED PLANES AND TRAUMATIC OCCLUSION

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DENTISTRY IS BECOMING MORE BASIC in its outlook and approach. The effects of this philosophy are evident in the evaluation, diagnosis, and treatment of the patient as a whole instead of isolated treatment of the mouth. Many of the solutions to the complexities in dentistry become more understandable and revealing with better integration and application of the basic sciences.

This article explains traumatic occlusion in terms of basic physical principles and their application in clinical practice.

BASIC CONSIDERATIONS

Eight basic factors are involved:

1. For every action there is an equal and opposite reaction (Newton's third law). The mandibular teeth deliver force to the maxillary teeth as a result of muscle action. In reaction, the maxillary teeth return an opposing force to the mandibular teeth.

2. A force directed against an inclined plane produces resultant vertical and horizontal forces. The sides of the cusps of the teeth are inclined planes, and thus the laws relating to inclined planes may be applied to them.

3. The steeper the inclined plane, the greater the magnitude of the horizontal force. High, unworn cusps can produce a greater horizontal force than shallow, worn cusps when the same amount of vertical force is applied.

4. The action on a tooth in traumatic occlusion may result in one or a combination of the following reactions: (a) the tooth may accommodate trauma and adjust to it by structural wear or by acquisition of greater support, or both, or (b) the tooth may not accept trauma and may move away from the force; if the latter occurs, periodontal disturbances result, with consequent loosening of the tooth, and (c) the tooth accepts trauma and transmits the reaction to the moving joint member, the mandible. This reaction is observed when the maxillary to mandibular tooth relationships change from the traumatic contacts to the final tooth contacts *without* any significant movement of the teeth themselves.

5. The mandible has two complex joints with a single connecting element, the mandibular body, which unites them as one. For every action at one joint, a reaction may occur at the opposite joint.

6. A healthy natural tooth is firmly attached to its jaw member, so force against a tooth may result in a reaction on the mandible, because the mandible is

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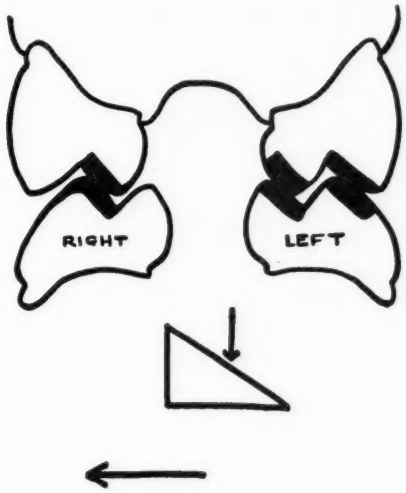

Fig. 1.—The horizontal component of displacement from the traumatic occlusion of the indicated inclined planes tends to shift the mandible to the right.

the moving element while the maxillae are the fixed elements. The mandibular teeth redirect their traumatic forces and influence, thus shifting the movements of the mandible.

7. The structure of the natural dentition is a complex arrangement of inclined planes in the form of mesial, distal, buccal, and lingual cuspal inclines.

8. A vertical force acting on an inclined plane produces a horizontal component of force directed away from the inclined plane. The movement of the mandible is in a direction away from the inclined planes involved in the traumatic contacts between the cusps.

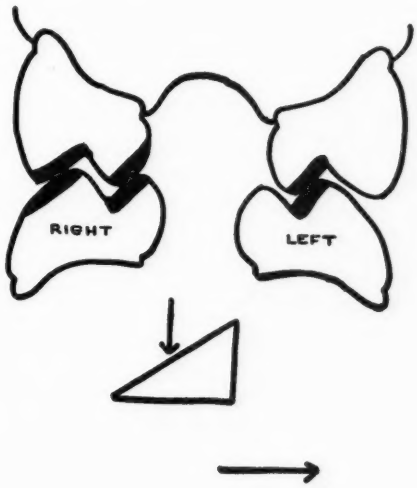

Fig. 2.—The horizontal component of displacement from the traumatic occlusion of the indicated inclined planes tends to shift the mandible to the left.

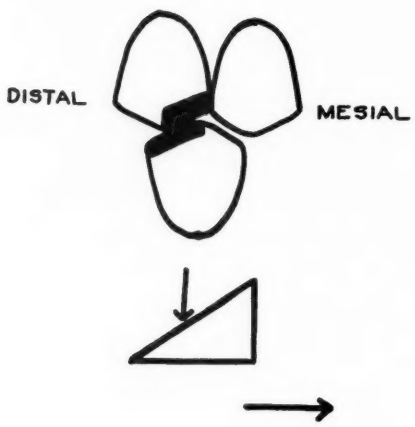

Fig. 3.—The horizontal component of displacement from the traumatic occlusion of the indicated inclined planes tends to shift the mandible anteriorly.

EXPLANATION OF THE PROCEDURE

Changes observed in maxillomandibular tooth relationships from initial traumatic tooth contacts to final tooth contacts *without* significant tooth mobility can be explained by a shifting of the mandible. The traumatic inclined plane relationships of the teeth influence this shift.

The mandible is capable of different basic shifting movements: (1) a lateral shift to the right or left side, (2) an anterior or forward shift, (3) a posterior or backward shift, and (4) combinations of these three movements.

Disharmony between the buccal and lingual cuspal inclines of the upper and lower teeth tends to shift the mandible in a lateral movement. Traumatic contacts of the mesial and distal cuspal inclines tend to shift the mandible in an anterior or posterior movement. Since the mandible shifts away from the inclined planes of the cusps that are traumatized, observation of the *direction* of the mandibular shift indicates which inclined planes are responsible for the movement.

TABLE I. DIRECTION OF MANDIBULAR MOVEMENT FROM TRAUMATIC OCCLUSION

MOVEMENT OF MANDIBLE	CUSP INVOLVED	
	MAXILLARY INCLINES	MANDIBULAR INCLINES
Right lateral	Right buccal Left lingual	Right lingual Left buccal
Left lateral	Right lingual Left buccal	Right buccal Left lingual
Anterior	Mesial	Distal
Posterior	Distal	Mesial

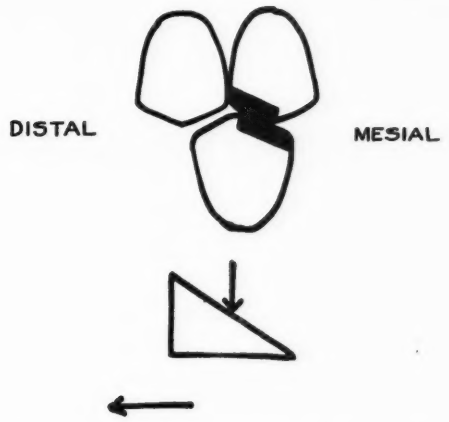

Fig. 4.—The horizontal component of displacement from the traumatic occlusion of the indicated inclined planes tends to shift the mandible posteriorly.

PRACTICAL APPLICATIONS

A shifting movement of the mandible to the right side results from traumatic contacts of (1) the right buccal inclines of the upper lingual cusps with the right lingual inclines of the lower buccal cusps or (2) the left lingual inclines of the upper buccal and lingual cusps with the left buccal inclines of the lower buccal and lingual cusps (Fig. 1).

A shifting movement of the mandible to the left side results from traumatic contacts of (1) the right lingual inclines of the upper buccal and lingual cusps with the right buccal inclines of the lower buccal and lingual cusps or (2) the left buccal inclines of the upper lingual cusps with the left lingual inclines of the lower buccal cusps (Fig. 2).

An anterior shift of the mandible results from traumatic contacts of the upper mesial cuspal inclines and the lower distal cuspal inclines (Fig. 3).

A posterior shift of the mandible results from traumatic contacts of the upper distal cuspal inclines and the lower mesial cuspal inclines (Fig. 4).

Table I summarizes the practical applications of mandibular movement as they relate to traumatic occlusion.

SUMMARY

Traumatic occlusion, inclined plane relationships, and mandibular shifting movements have been explained.

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A BALANCING APPLIANCE FOR COMPLETE DENTURES

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VERTICAL INSTABILITY is commonly designated as lack of retention. Without loss of retention, a certain amount of vertical movement of the entire denture base corresponds to the soft tissue resiliency and may be considered physiologic. The movement on the soft tissues causes a hydraulic pressure phenomenon that favorably distributes the stress on the supporting hard structures.

DENTURE INSTABILITY

A prosthetic restoration that rests on soft tissue follows certain physical laws that apply to a solid body floating on a fluid medium (mucous membrane). A peripheral force on the denture creates a turning movement with a depression of the pushed side and a rising of the opposite side (Fig. 1).

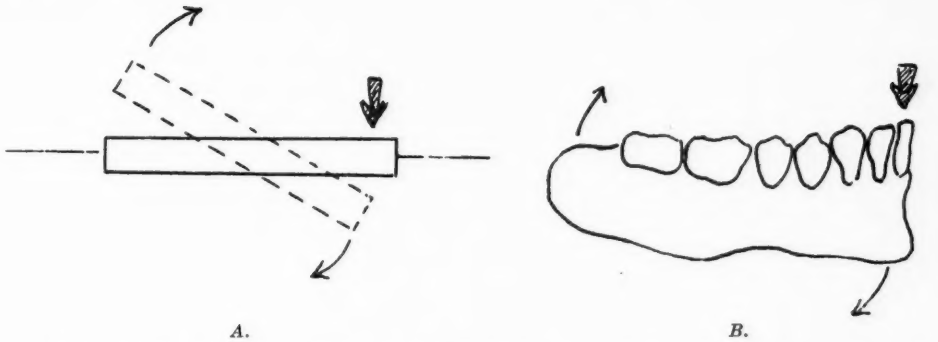
The first molar regions are of special importance in stability because they represent the transverse axis of the denture base. Because of the movements of torsion on this axis, the anterior residual alveolar base and the bone distal to the first molars atrophy to a greater extent than the bone in the first molar regions.[1]

The most common means to reduce these denture movements are (1) positioning the anterior teeth so that there will be no interference with the lower anterior teeth during function and (2) the use of flat cusp teeth. Accordingly, various forms of posterior teeth have been developed (French, Sears, Hiltebrant, Heintz). Generally, the lower tooth has a narrow section that acts as a pestle on the upper tooth, which is concave and functions as a mortar (Fig. 2).

It is impossible to transfer to dentures the laws that regulate natural teeth. The occlusal surface of a denture has little in common with that of natural teeth and must be considered functionally as a complete masticatory unit that can be stabilized only in its "baricenter."[2,3]

Gysi's concept that centric occlusion is preserved by the contact of all artificial teeth with pronounced cusps has been reviewed. Mastication does not occur with teeth in contact. On the contrary, food is chewed with the teeth out of contact initially, the teeth approach each other closer during the trituration stage, and the teeth come automatically into centric occlusion at deglutition.[2-5]

One method of arranging the teeth consists of placing only the second bicuspids and first molars into occlusal contact. These teeth have special importance in the stability of complete dentures, since they are located where upper and lower alveolar ridges meet on the sagittal plane—the point which is the masticatory baricenter (Fig. 3). The second molars are used only to increase the tissue support of the denture and do not make occlusal contact. The distal part of the



A. *B.*

Fig. 1.—A force acting on one end of a floating body creates a rotating movement. *A*, The displacing motion caused by a peripheral force on a floating body. *B*, The analogous behavior of a complete denture supported on soft tissue.

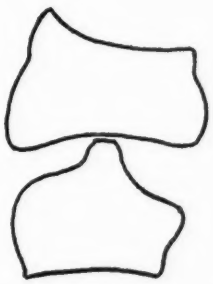


Fig. 2.—The posterior teeth are designed to reduce denture movements on the supporting tissues.

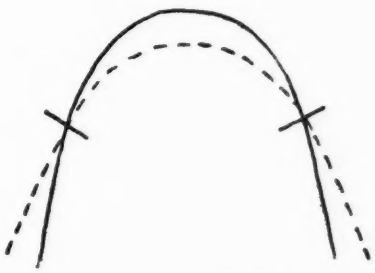


Fig. 3.—The solid line indicates the upper residual alveolar ridge; the line of dashes indicates the lower residual alveolar ridge. The masticatory baricenter is the junction point of both dental arches.

second molars is turned buccally to create more space for the tongue. The first bicuspids are placed out of occlusion approximately 0.5 mm., and the lower anterior teeth are placed 1 to 2 mm. from the upper teeth with sufficient vertical overlap that balancing contacts are maintained in the protrusive movements (Fig. 4). Heintz[2] states that even though occlusal contact takes place only on the masticatory center, almost all patients develop centric occlusion at this point in a short time.

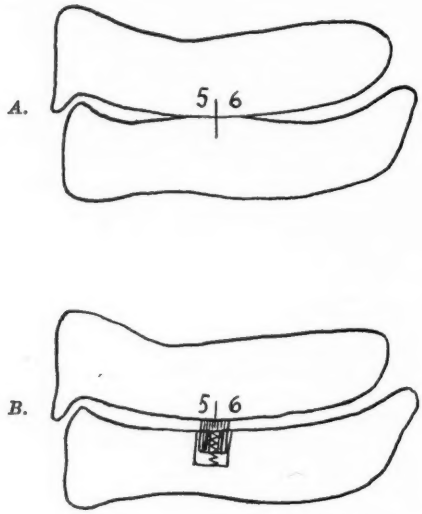


Fig. 4.—*A*, The arrangement of teeth as suggested by Heintz permits occlusal contact only at the masticatory baricenter. B, The contact at the masticatory center is established with the balancing plates.

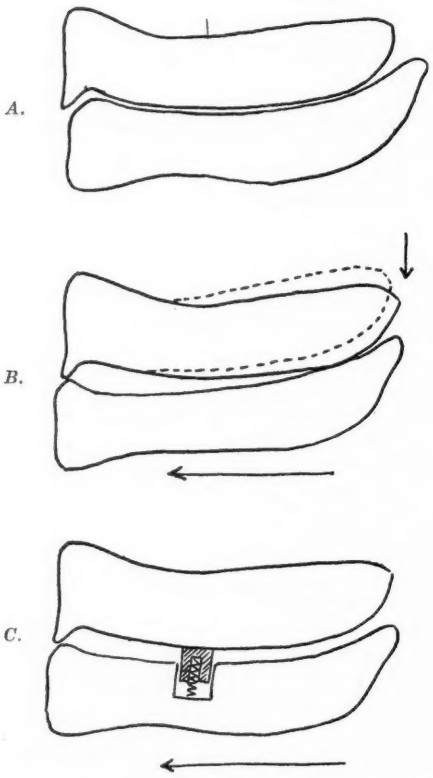


Fig. 5.—*A*, The dentures are in centric occlusion. *B*, A lack of balancing contacts in the protrusive position allows the posterior part of the denture to tip down. *C*, The balancing contacts in the protrusive position are maintained by the balancing plates.

BALANCING PLATES

In an attempt to overcome the problems connected with denture displacement, balancing plates are placed in the occlusal surfaces of the teeth in the masticatory centers. The purposes of the balancing plates are (1) better distribution of forces over the whole denture base (Fig. 4), (2) better denture stability on the sagittal and frontal planes during mandibular protrusion and incision (Fig. 5), (3) better trituration of food even when flat cusp teeth are used, and (4) longer lasting denture stability because of diminished stress on the supporting tissues.

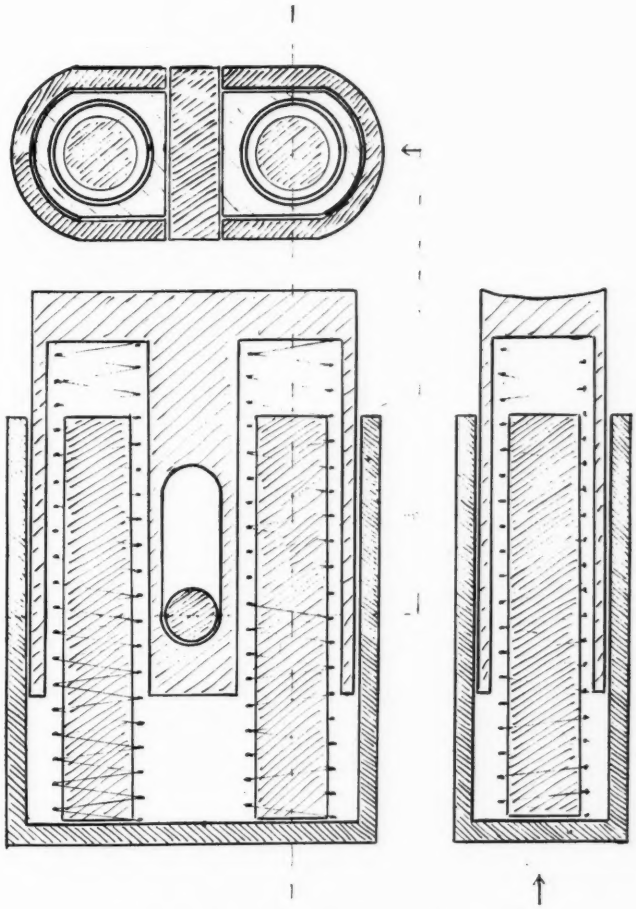


Fig. 6.—The internal sections of the balancing plate.

CONSTRUCTION OF BALANCING PLATES

The balancing plate may be compared to a stress breaker. The device consists of a plate moving in an airtight case. Two springs are inserted inside the plates into cylindric holes in the base of the case. The springs hold the plate approximately 2.5 mm. out of the case when the jaw is in rest position (Fig. 6). During

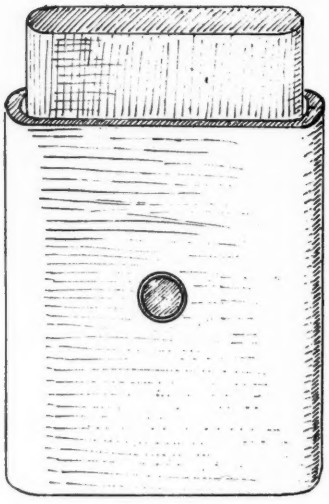


Fig. 7.—The external view of the balancing plate.

each masticatory stroke, the plate is pressed by the opposing occlusal surfaces into its seat, and in the following opening of the jaws, the plate returns to the original position.

Two metal cylinders are placed into the springs to eliminate dead spaces and prevent food stagnation in the appliance. The appliances are inserted in the lower first molars of complete dentures with self-curing acrylic resin so that the moving plate is just out of contact with the opposing teeth when the jaw is in rest position. The cusps of the upper first molars are ground to allow free movement of the balancing plates in lateral and protrusive mandibular excursions (Figs. 7 and 8).

ADDITIONAL USES

The balancing plates are useful for treating some nervous habits, such as bruxism, especially when their origin is the lack of confidence of the patient in the vertical stability of the dentures. The devices are indicated also for masticatory in-

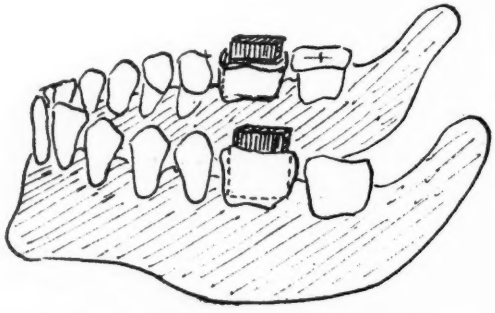


Fig. 8.—The balancing plates are inserted into the lower first molar teeth.

sufficiency caused by the use of cuspless teeth, muscular atrophy, or the inability of the supporting tissues to absorb the normal masticatory stress. Patients who wear dentures with balancing plates report improved functional ability in the mastication of food.

SUMMARY

Balancing appliances that are inserted in the first molars of the lower denture have been described. The balancing plates improve the functional and biologic properties of the dentures.

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TROUBLE SHOOTING IN COMPLETE DENTURE PROSTHESIS

Part X. Nerve Impingement and the Radiolucent Lower Anterior Ridge

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THE PAIN AND DISCOMFORT that a patient may experience from lack of or improper relief of the incisive fossa and the mental foramen may be so severe as to simulate facial neuralgia and lead to a complete failure of the dentures.

ANATOMY

The incisive fossa and foramina are situated immediately behind the upper central incisors (Fig. 1). Four canals are present on the bottom of this fossa: two branch off laterally to the right and left nasal fossae (the foramina of Stensen); two, one in front and one behind, lie in the midline (the foramina of Scarpa).

The anterior or terminal branches of the descending or posterior palatine arteries which ascend from the mouth to the right and left nasal fossae pass through the foramina of Stensen. The foramina of Scarpa transmit the nasopalatine nerves, the left passing through the anterior and the right through the posterior canal.

The mental foramen is situated just below and between the level of the apices of the two lower bicuspid teeth and transmits the mental vessels and nerve. The mental vessels are branches of the inferior alveolar artery, a branch of the internal maxillary artery. The mental nerve is from the inferior alveolar nerve, a branch of the third division of the fifth nerve. The mental artery leaves the mental foramen with the nerve, supplies the structures composing the chin, and anastomoses with the submental and inferior labial arteries. The mental nerve emerges from the bone at the mental foramen and divides beneath the triangularis muscle into two or three branches. One branch descends to supply the skin of the chin, and another (sometimes two) ascends to supply the skin and mucous membrane of the lower lip. These branches communicate freely with the facial nerve.

DENTURE PRESSURE

The anterior (incisive) fossa usually is not protected with an adequate thickness of soft tissues, and the blood vessels and nerve entering the foramina are in close contact with its bony margins. Under these circumstances, undue pressure upon this tissue may impair the circulation of the blood in the nasal fossae.

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*Part I, J. PROS. DEN. 9:978-987, 1959; Part II, 10:42-46, 1960; Part III, 10:263-269, 1960; Part IV, 10:490-495, 1960; Part V, 10:682-687, 1960; Part VI, 10:887-890, 1960; Part VII, 10:1022-1028, 1960; Part VIII, 11:79-83, 1961; Part IX, 11:244-246, 1961; Part X is the final article of this series.

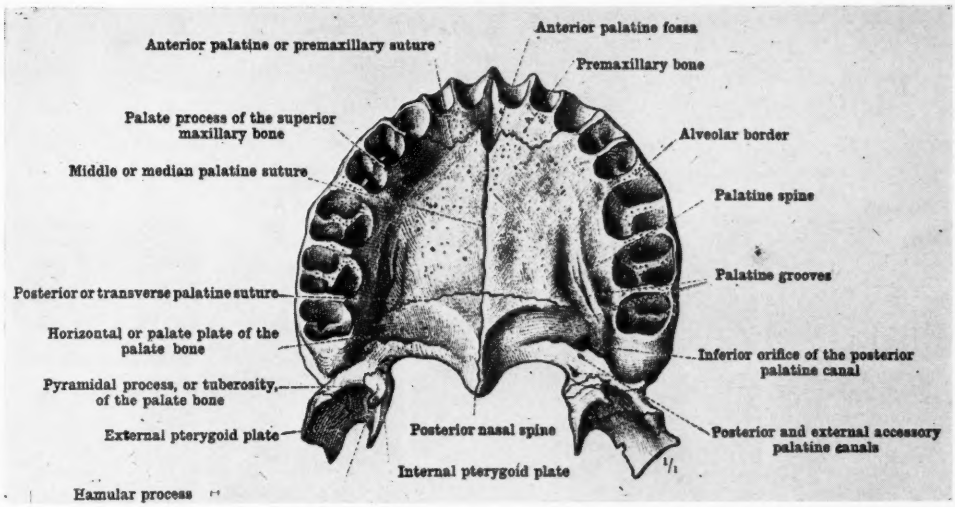
Anterior palatine or premaxillary suture
Anterior palatine fossa
Premaxillary bone
Palate process of the superior maxillary bone
Alveolar border
Middle or median palatine suture
Palatine spine
Palatine grooves
Posterior or transverse palatine suture
Horizontal or palate plate of the palate bone
Inferior orifice of the posterior palatine canal
Pyramidal process, or tuberosity, of the palate bone
External pterygoid plate
Posterior nasal spine
Posterior and external accessory palatine canals
Internal pterygoid plate
Hamular process

Fig. 1.—Artificial teeth should be set as closely above the alveoli as possible anteroposteriorly and buccolingually. This provides adequate tongue space and the proper relationship between the artificial teeth, the buccinator and orbicularis oris muscles, and the anterior and posterior palatine foramina. (From Toldt, C.: An Atlas of Human Anatomy, ed. 2, New York, 1944, The Macmillan Company, vol. 1, p. 97.)

Pressure upon the nerve that enters the foramina of Scarpa may be the cause of various syndromes. Burning palate and burning mouth comprise one of these syndromes. It is not so much the pain as the fear of cancer that is disturbing to the patient. A burning sensation or continuous smarting in the nostrils is a frequent concomitant of excessive pressure. The pressure need not necessarily be direct and continuous. An intermittent pressure, as seen frequently with a complete upper

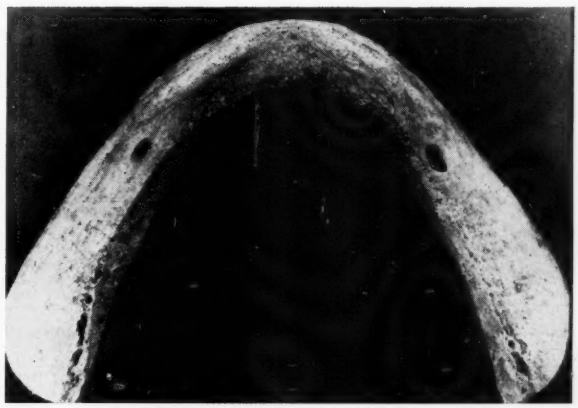

Fig 2.—The mental foramen is exposed near the crest of an atrophied lower ridge. The pressure of a lower denture upon the exposed mental nerve and vessels that pass from the foramen to the lower lip and chin causes the patient much pain and discomfort. Severe numbness of the lip and chin associated with a peculiar mild burning sensation is the most common complaint of patients with this situation. (Courtesy of Dr. Q. Hirschfeld.)

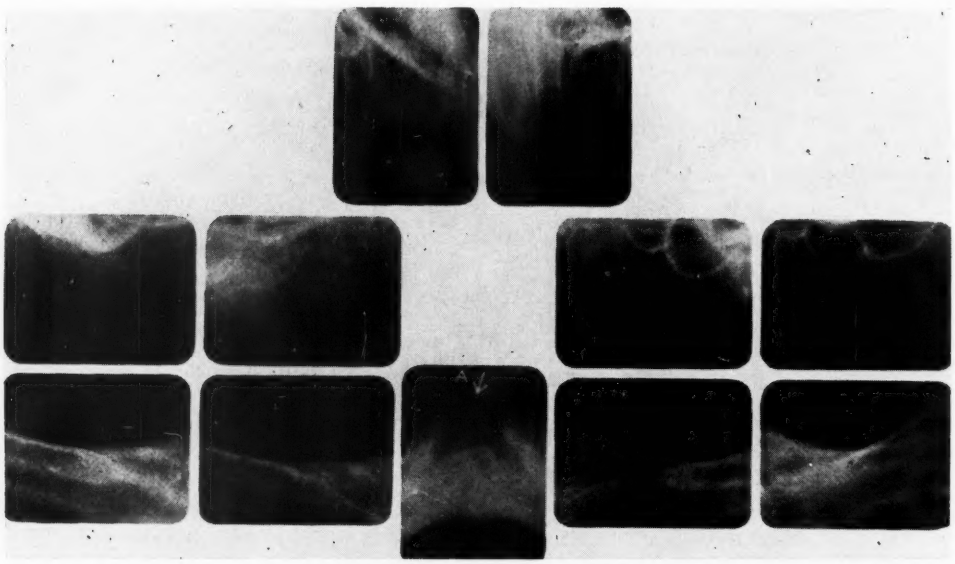

Fig. 3.—Nutrient canals in the region of the six lower anterior teeth must be relieved carefully so that the denture will not impinge upon the sharp points of the bone while moving in function. (From Landa, J. S.: Practical Full Denture Prosthesis, ed. 1, Brooklyn, 1947, Dental Items of Interest Publishing Co.)

and a partial lower denture, may be the cause of severe pain. The same condition prevails with complete dentures when the upper denture moves forward in function and exerts undue pressure upon the incisive fossa. Tenderness of the tissues over the foramina, with radiation of pain in various directions over the oral cavity and even over the face, is caused by such unstable upper dentures.

When considerable resorption of the alveolar process has occurred, denture pressure upon the mental nerve and blood vessels may cause pain or numbness in the lower lip and chin (Fig. 2). Here too the patient frequently is frightened into believing that the numbness is the forerunner of cancer, and cancerophobia is the usual consequence. Careful digital examination may show that the mental foramen is completely exposed upward, and the slightest contact of the finger with the mental nerve evokes a violent reaction of pain. Further digital examination frequently reveals a nodule which moves freely about 3 to 4 mm. in all directions. When the finger makes even light contact with this nodule, severe pain is experienced by the patient.

This nodule represents a loop formed by the mental nerve and blood vessels in their new relation to an atrophied mandible. In many instances, careful but generous relief of the tissue surface of the denture at a location corresponding to the nodule gives prompt relief of the pain and numbness in the lip and chin.

RADIOLUCENT LOWER ANTERIOR RESIDUAL ALVEOLAR RIDGE

All too frequently denture patients complain of pain in the anterior segment of the lower residual alveolar ridge. Three reasons are the probable causes of pain.

First, the residual alveolar ridge in this region consists mainly of cancellous bone which is least adapted to give adequate support to a complete denture. Second, the residual alveolar process frequently contains nutrient canals in the interproximal spaces or on the labial surface (Fig. 3). These nutrient canals parallel the long axes of the teeth. Some extend to the positions of the apices of the teeth, others stop at various distances from the apices (Fig. 4). The interruption of the residual alveolar process by the nutrient canals creates irregular, sharp points and projections which are a liability as a basal seat for dentures. Third, the settling of lower dentures is in a downward and lingual direction, which causes pain on the labial surface of the lower anterior ridge.

The anterior segment of this type of an alveolar process should be relieved generously at the time the denture is constructed, or the lower denture should be rebased during the period of adjustment. Care should be taken in the rebasing procedure to relieve the entire anterior segment of the alveolar ridge with well-adapted 21 gauge tinfoil. Such relief forestalls contact of the denture with the anterior segment of the lower ridge until complete settling of the denture takes place. By that time the brunt of the masticatory forces is supported by the bicuspid-molar segments of the ridge, and only occasional relief may be required in the anterior segment.

Here, as in any other area of prosthodontics, correct occlusion is the greatest insurance for success. Dentures must not be delivered unadjusted, as they come from the laboratory. New, unstrained centric relation records should be secured and the dentures mounted on an adjustable articulator. Then the occlusion should

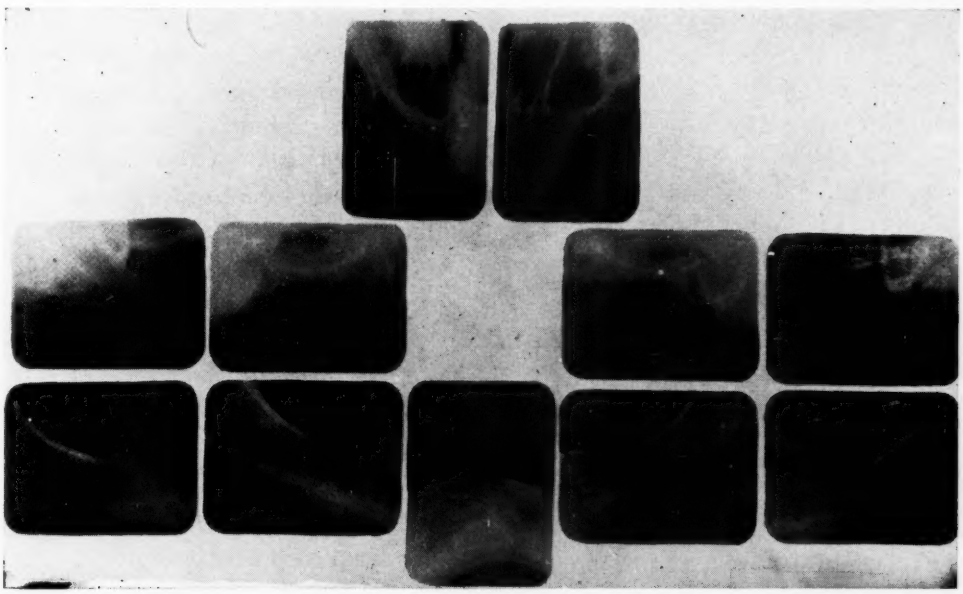

Fig. 4.—A generalized, well-calcified bone pattern of the residual alveolar process should be taken into consideration in the diagnosis and prognosis of complete dentures. (From Landa, J. S.: Practical Full Denture Prosthesis, ed. 1, Brooklyn, 1947, Dental Items of Interest Publishing Co.)

be corrected so that it is in harmony with centric jaw relation and with the protrusive and lateral excursions of the mandible. The centric occlusion should be in perfect vertical equilibrium.

When adjusting the occlusion for protrusive and lateral mandibular excursions, all horizontal interferences should be eliminated. If adjustable articulators are not used, the patients would be benefited by remounting the dentures on a plane-line articulator and adjusting the occlusion to harmonize centric occlusion with centric jaw relation.

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ESSENTIALS OF COMPLETE DENTURE SERVICE

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This article was written to point out areas of disagreement among prosthodontists regarding prosthodontic procedures and principles. Obviously, it must be classed as a mild satire, and it must not *be misinterpreted to mean that the various procedures mentioned are not necessary. The quotations used have been taken out of context, and consequently the meaning intended by many of the authors has been distorted. It is intended that the reader will recognize from this article that all of the operations used in prosthodontic treatment must be related to all other operations in dental treatment. When this is done, certain operations are unnecessary, but compensation for the omissions is made by other steps in the procedure.*

IN AN EFFORT TO DETERMINE the essentials of complete denture service, I have searched the literature for the operations which authors have said are nonessential. If the nonessentials are eliminated, one can assume, that which remains is essential.

Kettlewell[1] said, "The dental literature contains many splendid articles, explaining how dentures should be constructed. Some deal with the ideal occlusion, an all-important factor. Others deal not only with this abstract subject, but present methods [which] are too complicated for the average dentist to pursue."

Sears has pointed out that speed in dental operations is not due to rapidity of motion but to the elimination of unnecessary motions. I shall cite passages which may indicate some of the unnecessary motions.

Moses[2] asked, "Could it be that some of the concepts which we have established as being desirable in complete denture procedures are unnecessary and a waste of time?"

Trapozzano and Lazzari[3] said, ". . . Many of our concepts and techniques are based upon evaluations placed upon them by individuals who too frequently are in reality stating opinions and not facts."

So, what are the essential facts?

IMPRESSIONS

Impression techniques have been discussed in many articles. Most of the techniques described have been good and have been devised to provide the maximum support, stability, and retention for dentures. However, many of the procedures are exacting and time consuming.

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In the search for nonessentials in impression making which might be eliminated in order to save time, several pertinent comments were found.

DeVan[4] said, ". . . The importance of the impression phase has been overemphasized."

Tuckfield[5] said, ". . . The securing of a good impression does not mean a successful denture."

Albinson[6] wrote, ". . . [The] function [of denture flanges is] to stop the denture from skidding on the tissues, something that surface tension is helpless to prevent. It has been emphasized and re-emphasized that this is the *only* function of the flanges. Their '. . . depth, detail and outline form have no value . . .'[7] for anything else."

Tuckfield[5] commented at length on this subject: "Some practitioners do not appear to think that comparatively large buccal extension can be made in the majority of cases. . . . Advocates of the mucostatic impression methods . . . make two claims . . . first [by Dykins], that there is no need to cover a large area and, second [by Cunningham, Pope, Chartrand, and McGinnis], that the margins of the denture should be made razor sharp. . . . One writer [Dykins] states that there is no need for any depth of flange except to prevent lateral movement of the denture, and he compares it with the flange of a railway wheel where the flange is necessary only to keep the wheel on the rail."

Colburn[8] stated, ". . . The final answer is that muscle trimming is not indicated, necessary, or desirable at any time in the outlining of a maxillary or mandibular impression."

The use of relief in dentures may be disregarded according to Parry[9]: "It would seem more logical to omit the palatal relief and to permit the basal bone of the palate to receive its share of the stresses."

From these comments, it might be assumed that there are few essentials in the problem of impressions.

However, it remained for Tilton[10] to provide the ultimate in time saving in impressions when he said, ". . . The patient makes his own impressions."

ORIENTATION OF CASTS ON THE ARTICULATOR

Of all of the prosthodontic procedures taught in dental schools, it is likely that the use of the face-bow is the first to be omitted by dental graduates. No doubt commercial dental laboratories have had an influence in this direction, but many dental authors have written about its lack of importance.

Most techniques in common use do not require the mounting of casts in relation to cranial landmarks. Among these are the techniques of Hanau, Gysi, Terrell, Stansbery, and House.

The existence of a hinge axis is questioned by Vaughan,[11] who said, "These muscles [the external pterygoids] permit an anteroposterior adjustment of the interarticular elements, which . . . makes it physiologically incorrect to continue the use of the word 'hinge' in describing any portion of the action of this joint."

McKevitt[12] wrote, "Bennett showed that no single rotation center existed, but that the center of rotation changed constantly."

In his article entitled "There Is No Usable Vertical Opening Axis in the Mandible," Clapp[13] stated, "All the axes for this movement, except the one for extreme opening, are located outside the mandible."

Granger[14] said, "In a series of 3,000 face-bow mountings, not a single patient closed in either centric relation or centric occlusion when he bit into the bite fork."

Kurth[15] quoted Craddock as saying, "But the search for the axis, in addition to being troublesome, is of no more than academic interest; for it will never be found to lie more than a few millimeters distant from the assumed center in the condyle itself."

Kurth and Feinstein[16] stated, "It is most unlikely . . . that the hinge axis can be located with any degree of accuracy."

Sears[17] apparently believes that the location of the hinge axis is of no importance since "we can no longer assume a permanent hinge axis because displaced condyles can cause the anatomic axis to shift."

"Since there is no attempt to imitate jaw movements the hinge axis is of no importance," Porter[18] has said. In another article[19] he said, "The mounting of casts in orientation with the hinge axis certainly can be of no value . . . . They constitute an innocuous pastime for the dentist."

Apparently he agrees with Stansbery,[20] who called the face-bow "a useless if harmless toy."

Craddock and Symmons[21] said, ". . . When, instead of making individual face-bow transfers, all casts are mounted at an average distance from the intercondylar axis . . . the resulting errors in the occlusal relations of full dentures are so small as to be incapable of clinical detection."

"Schlosser contends that although the arbitrary axis is not precise, it is close enough for all practical purposes. . . ."[22]

Collett[23] stated, "An empirical face-bow transfer, carefully accomplished, is within a few millimeters of a kinematic transfer. The occlusion is about 100 millimeters distant from the opening axis; therefore, it is questionable if the additional accuracy . . . warrants the additional effort."

Jamieson[24] said, ". . . The arbitrary technique of transfer as advocated by Hanau with face-bow model 'C' is acceptable."

Pleasure[25] ignores the face-bow altogether: "I do not use the face-bow in complete denture work; I mount the upper cast by means of a jig on the articulator."

From these comments, it might be assumed that the face-bow is not essential and that 5 minutes could be saved if the arbitrary face-bow is not used, 30 to 60 minutes if the kinematic face-bow is not used.

JAW RELATIONS

Maxillomandibular relations may be considered as vertical or horizontal relations. The vertical relations are the vertical dimensions of occlusion and of rest position. The horizontal relations are centric relation and the various eccentric relations. These will be considered separately.

Vertical Dimension.—It is unfortunate that most of the excerpts from articles I have selected do not designate the class of vertical dimension under discussion. However, it is apparent that most of them refer to the vertical dimension at which occlusion takes place.

Block[26] conceded, ". . . I am forced to agree with Swenson who says, 'The only definite statement that should be made (regarding vertical dimension) is that it is an indefinite procedure.' "

"Any method [for determining vertical dimension] which works well in the dentist's hands is acceptable, as there is no known sure way of obtaining this measurement," Austin[27] said.

Sloane[28] suggested that "a patient . . . can accommodate to a new rest position . . . ."

Atwood[29] found that "variability [in rest position] was measurable and of clinical significance in edentulous patients between different readings within a single sitting, between average readings of different sittings, and between readings with and without dentures."

Porter[18] concluded, "The vertical jaw relation is not a mechanically precise position . . . . The judgment of the prosthetist should be the final deciding influence."

If these statements are correct, the determination of vertical dimension is not essential and only a minimum of time need be spent on it.

Centric Relation.—While most authors accept the establishment of centric relation as an essential procedure in the construction of dentures, there are some who do not.

Rader[30] wrote an article entitled "Centric Relation Is Obsolete." In it he said, ". . . Centric relation, itself, is unsound in principle . . . ." He continued, "No part of this [centric] relationship can be transferred to an articulator, except the horizontal relation of the alveolar ridges."

Moyers[31] stated, "The concept of a fixed and immutable centric relation is contrary to all that is known of neuromuscular physiology."

"Others maintain that in its ideal or centric position the mandible is slightly in front of its most posterior position," Sicher[32] stated.

Boos[33] reported, "In . . . 35 per cent of patients, there is a tendency for the jaw relation to be forward of the posterior terminal position."

Robinson[34] observed that ". . . the concept of the centric position stands out as the vaguest and most ambiguous . . . ."

Granger[14] suggested, ". . . The patient rarely . . . chews in centric relation . . . . If he does not chew in centric relation, why worry about it?"

The various methods for recording centric relation have been questioned.

Moses[35] stated, ". . . It has been proved that the Gothic arch tracing is not absolutely accurate . . . ."

Porter[36] wrote, "Mr. Page ventures . . . the thought-provoking observation 'that the Gothic arch tracing is a fallacy should be apparent from simple geometry . . . ' "

"The most perfect centric check bite and mounting are worthless where the type of occlusal surfaces has been or is to be changed," said Albinson.[37]

Trapozzano[38] contended, "The use of the central bearing point is based on the fallacious assumption that the central bearing point will produce equalization of pressure . . . . It is impossible to register equalization of pressure with a central bearing point. The same holds true, but to a greater degree, if eccentric records are obtained by the use of the central bearing point."

Kingery[39] supports Trapozzano's contention: "Too long we have looked upon the central bearing point as assurance for equilibrium of contact regardless of its position. This is a fallacy."

The wide variation in concept, equipment, and method for determining centric relation seems to allow considerable latitude and to indicate that it is not essential.

Eccentric Relations.—Several authors see either a limited value in making eccentric jaw relations or none at all.

Porter[18] said, ". . . Many of the more complex and intricate procedures provide only an interesting hobby for the dentist, which benefits him more than his patient."

Campbell[40] wrote an article entitled "Why Measurements of the Mandible, Tracing of the Condyles, the Construction of Hypothetical Triangles and the Use of the Face-Bow, Are All Nonessential to the Construction of Full Dentures Possessing the Highest Degree of Efficiency."

Kurth[15] said, "It doesn't make any difference what technique is used to set these condylar adjustments . . . . The determination of the value of the condyle path has been questioned."

". . . In a vast majority of full denture cases registration of the inclination of the condyle path is entirely unnecessary," Owen[41] stated.

Craddock[42] said, ". . . Individual measurements of condyle path inclination and adaptable articulators [do not] contribute anything essential to the excellence of the result."

Porter[18] claimed that ". . . protrusive or lateral check bites [are] not essential, nor even desirable, in the construction of dentures of the highest type of efficiency."

Sears[17] suggested a more or less arbitrary adjustment of the condylar guidances: "Not only do we lengthen the posts in anticipation of the descent of the condyles in centric jaw relation, but we also increase the steepness of the condyle indications on the articulator so that as the dentures are worn the teeth will fall gradually into the desired occlusions in the new eccentric relations."

These statements would seem to indicate that eccentric maxillomandibular records are not essential.

ARTICULATORS

Some articulators are more complicated than others—at least they require more adjustments and more interocclusal records. Certain authors have questioned the value of the more complicated instruments.

Pleasure[25] said, "We rely on the articulator to do only what it can do well, i.e., retain centric relation and vertical dimension. . . ."

Terrell[43] said, "It is possible to build good dentures by using any of the articulating instruments. The mouth can even be used as an articulator."

Schuyler[44] said, "Dentures made upon the Gnathoscope would show no greater or no less degree of accuracy in tooth intercuspation in the centric maxillo-mandibular position than would similar dentures made upon the Hanau or Gysi articulators, the Hooper duplicator, or a barn door hinge, provided the casts have been mounted with the same centric relation records, and provided the vertical dimension remained unchanged."

Meyer[45] stated, ". . . The second great source of error, is the . . . anatomic articulator . . . ."

"A simplex or arbitrary type of instrument is entirely adequate," Porter[18] stated.

Kurth[15] held, "The value of an adjustable articulator as an aid to obtaining a balanced occlusion can be questioned."

McKevitt[46] said, ". . . Correctly established vertocclusion mounted on a Simplex articulator will obviate the use of Gothic arch tracings, check bites, and the adaptable articulator."

Sears[47] suggested making the mouth fit the articulator adjustment: ". . . We no longer consider the dental articulator as a mechanism for reproducing exactly the various jaw relations found in the patient's head; nor should the dentures present balanced eccentric occlusions when they are first installed . . . . We need to use the dental articulator to anticipate the jaw relations desired, and to adjust the mechanism accordingly instead of adjusting to the relations discovered on the patient."

If so many different articulators may be used successfully, and in so many different ways, it is possible that the simplest one could be used and the others could be considered as not essential, or the mouth might be used instead of an articulator.

POSTERIOR TOOTH FORMS

Many authors suggest the use of teeth with modified occlusal forms.

Beresin and Beresin[48] said, "One is forced to conclude that the cusps of natural teeth, when reproduced in artificial teeth, may be both undesirable and harmful."

Porter[19] said, "Posterior teeth are used which possess the following specifications: (1) no cusp height; (2) sharp cutting ridges . . . ."

". . . We are justified in deviating from anatomical forms in order to gain greater efficiency," said Sears.[49]

Moses[50] claimed that "cusps with steep incline planes create potential factors of tissue breakdown, both with natural and artificial teeth."

DeVan[51] recommends that "the form of the posterior teeth should be devoid of inclines [and] the number of the posterior teeth may be reduced from four to three in each sector."

Cohen[52] reported, "Many dentists cling to the theory that almost any tooth form in the mouth will be satisfactory. They believe the condyle path is not constant; that its path is entirely dependent upon the shape of the anterior guidance.

They claim that the condyle of the mandible is a universal joint and therefore will follow any course in which it is directed."

French[53] quoted Gysi as saying, ". . . I often make all bicuspid dentures, using no molars at all, to protect the tissues under the denture from traumatic injury."

Porter[18] said, "Even though a perfection of excursive occlusion may be accomplished . . . it cannot be maintained during the progressive vertical closure which occurs as dentures are worn. These considerations definitely rule out the use of cusp teeth . . . . Just as cusp teeth constitute a disturbing and traumatic influence, so does the setting of teeth to a compensating curve which acts, in effect, as one large cuspal incline. A flat plane arrangement . . . is of a paramount importance. No contact of anterior teeth nor of second molars should be permitted in centric relation."

Brown[54] said, "After the treatment with the Sears occlusal pivots, and when all of the symptoms are eliminated, then, if the operator has his own ideas of the occlusal plane, or type of occlusal anatomy, or the degree of cusp height, he can then make his usual type of dentures."

Block[26] summarized the situation by saying, ". . . Posterior tooth selection is governed chiefly by principles involved in the technique being followed."

In these comments, it can be seen that some authors use bicuspids instead of molars, some omit cusps from teeth, some keep certain teeth out of contact, and some omit certain teeth. If all of the teeth were left off the dentures, much time could be saved in their construction and the teeth could be considered nonessential to dentures.

BALANCED OCCLUSION

There is much discussion about balanced occlusion in the literature. Some believe it to be impractical and even undesirable.

According to Boswell,[55] Prime said, ". . . Enter bolus, exit balanced occlusion."

Moses[35] observed, "There is no use talking about stability or balance with a bolus of hard resisting food in the mouth."

In another article Moses[2] said, "A startling revelation in Jankelson's work is the fact that while a bolus of food is being chewed and softened the chewing teeth do not meet. They meet whenever possible in centric occlusion, *after the food is swallowed*. Therefore, the type of balance which has been highly regarded for years contributes very little to efficient mastication. DeVan deliberately ignores the eccentric balancing movements on an adjustable articulator, but carefully obtains a balance in centric occlusion which is in centric relationship and at the exact vertical dimension. He employs a flat occlusal plane." Moses continued, ". . . The average patient with the average nonbalanced dentures performs masticatory functions as well as, and in some instances better than one with so-called balanced occlusion."

Rader[30] said, ". . . Centric relation, lateral motions, condyle paths, balance, and kindred precepts are wholly obsolete."

Kurth[15] quoted Druw as saying, ". . . There never has been, and there never will be, an occlusion which conforms to the accuracy demanded by a geometric asumption."

Kurth[15] also quoted Lauritzen as saying, "Patients with a natural dentition always will close their jaws in centric occlusion. As judged conservatively by the author this centric occlusion, in fifty per cent of all patients, is not a true centric or hinge occlusion but a convenience bite." Kurth continued, ". . . Those occlusions which function on the hinge axis are the ones in malocclusion . . . ."

Shanahan[56] said, ". . . Lateral and protrusive movements . . . are recognized as abnormal movements . . . and . . . should not be used for conforming the occlusal surfaces of every replacement or restoration."

Kettlewell[1] said, "Maxwell came to the conclusions that it was impossible to synchronize inclined planes of the teeth throughout the mouth as outlined by Monson . . . ."

The variations in technique are noted by Perkins[57]: "Kurth, Pleasure, and Stansbery all have conflicting methods of developing the curve of occlusion with equal success . . . ."

McKevitt[46] believes that "without a single exception, the natural order of the curve of Spee is wholly abrogated in the prosthetic scheme."

Augsburger[58] stated, ". . . The precise location of the occlusal plane within the patient's denture space is a nebulous concept . . . ."

Sears[17] ". . . challenges the concept that the dentist must accept whatever temporomandibular relations are found at the beginning of denture construction." Also, ". . . the better informed dentists have set the twelve anterior teeth out of occlusion in centric jaw relation." And, "to the several objections to meshing teeth must now be added the objection that they may force the condyles horizontally into strained relations in their sockets. Where the condyles are already in such strain, new dentures made to the same jaw relation and held there by intercusping teeth tend to perpetuate the abnormality."

He suggested further, "A simple way to apply the pivoting principle and observe the consequent changes is to build the elevations on the molar teeth . . . ."[17]

Brown[54] agrees with Sears: "In order to provide for the pivoting action as advocated by Sears, it is necessary to simulate, on the instrument, the condition in the temporomandibular joint as it should be when it is corrected—that is, the condyles should be out of contact with the mandibular fossae of the temporal bones."

In my search for nonessentials regarding occlusion which might be eliminated, I found that cusps, parts of teeth, and all of certain teeth could be omitted, also that certain teeth could be kept out of contact and that a heavy molar contact could be developed. Perhaps balanced occlusion could be classified as nonessential and a few posterior teeth could be set haphazardly and thus save time.

INTEROCCLUSAL DISTANCE

For a time it appeared all authors agreed that there must be interocclusal clearance and that the only question related to its magnitude.

However, Silverman[59] said, ". . . Principles and techniques based upon the physiologic rest position, and the free-way space . . . should be repudiated . . . in the thinking and the practice of dentistry."

THE NEED FOR DENTURES

It seems I was destined to be disappointed in the hope that I would find one thing essential in denture construction.

Up to this point, most of the procedures used in making dentures have been found not to be of primary importance or not essential. The application to the fullest extent of the information assembled would certainly reduce the time spent in making dentures. However, in the search for nonessentials in complete denture service, I have discovered that one can go still further.

French[60] said, "Young patients can wear almost anything."

Young[61] stated, "O'Rourke and Miner have pointed out that the cooking process so prepares foods that the essential need for comminuting function is greatly reduced."

Yurkstas and Curby[62] reported, "Relatively small forces were required for the mastication of most foods commonly found in the diet."

Kettlewell[1] asked, ". . . What percentage of people reduce their food to this semiliquid mass?" He continued, "There are some who do. May it be recorded here that those who accomplish this before swallowing their food are but a small fraction of 1 per cent . . . . Full dentures are but a 'crutch' . . . ."

Young[61] credits Campbell as saying, "Artificial teeth are an unnecessary luxury in this day of household and kitchen implements which can do a better job of food comminuting than either the natural or artificial teeth." In another article, Young[62] quoted Campbell as having said that "dentures are a luxury, and a nonessential for the preparation of foods or for the maintenance of good health."

Orban[64] observed, ". . . All living tissues and organs have a relatively wide range of adaptability to changing functional requirements."

On the basis of these quotations, even the making of dentures is not essential. It should be noted, however, that no author has suggested fees should not be charged for denture service.

EXPLANATION

In fairness to many of those who have been quoted, it must be remembered that their words were taken out of context. Many of the quotations referred to special techniques in which the statements were quite reasonable and correct. Taken out of context and not related to specific techniques, many of the statements are absurd.

I apologize publicly to those whose *ideas* have been distorted by the way in which they were used.

CONCLUSIONS

1. Successful complete denture treatment involves many interrelated operations. None of them can be slighted or omitted without making corresponding compensations in other procedures.

2. Differences of opinion lead to progress and re-evaluation of the validity of concepts and techniques.

3. Differences of opinion stimulate the search for basic principles in prosthodontics.

4. Authors and clinicians are obligated to explain why an operation is unnecessary in their techniques and to tell why and how its omission is compensated for in the other steps in the technique. If this is done, dentists will not be so confused by the articles they read and the clinics they attend.

5. If this article stimulates an inquiry into the "basic principles" of prosthodontics, much good can come of it.

6. The list of references can serve as a guide to the controversial areas of prosthodontics.

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PREPARATION OF MOUTHS FOR FIXED AND REMOVABLE PARTIAL DENTURES

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MOUTH PREPARATION for removable partial dentures is a necessary and exacting phase of clinical dentistry, but it is shamefully disregarded by many. This omission may be traced to several sources: (1) some franchised laboratories which advertise and exploit systems and methods, whether or not they are applicable, (2) manufacturers who furnish the materials and control the laboratory operations, (3) common inertia, (4) the importance of magnified profits to an overly large segment of the profession, and (5) the attitudes in many colleges where partial prosthodontics is taught by men whose interest and knowledge are in complete dentures and who feel and practice that removable partial prostheses are short-term, interim replacements.

When mouth preparation is proposed for either fixed or removable partial prostheses, many dentists will reply, "This is all right for a teaching institution, or for the big boys with wealthy patients, but give *me* a practical solution." By a practical solution, these men apparently mean "one in which the dentist makes a significant amount of money, with minimal effort, and the patient does not become unhappy too soon."[1]

There is a puzzling resistance to the truly practical approach to mouth preparation, an approach which keeps in mind the preservation of the remaining teeth, their supporting structures, and the subjacent tissue. Restoration, preservation, prevention, stability, comfort, and maximal efficiency are the results of this concept, which is carried out in accordance with a carefully predetermined plan.[2-5]

OBJECTIVES OF MOUTH PREPARATION

Fixed Partial Dentures.—Mouth preparation for a fixed partial denture entails prophylaxis, possibly gingival treatment or recontouring, alveoloplasty, equilibration,

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Read before the Section on Partial Prosthodontics at the Centennial Session of the American Dental Association in New York, N. Y.

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Fig. 1.—*A*, A removable partial denture made without adequate preparation of the mouth. *B* and *C*, Roentgenograms showing periodontal damage resulting from the inadequate mouth preparation. *D*, Properly formed rest seats were prepared in restorations on the abutment teeth. *E* and *F*, The health of the periodontal structures has improved and the teeth have become firm after a new partial denture has been worn for 5 years.

and exploration of all associated teeth and parts. An "associated" tooth is one which, if lost or rendered inefficient, would change or enlarge the plan of treatment originally outlined for the given dental arch. An associated tooth may be one approximating an abutment, it may be one which could be used as a splinted abutment, it may be a tooth the loss of which might weaken the presently competent support around an abutment, or it may be in the opposing arch.

The loss of an occluding tooth could necessitate the construction of a replacement which would receive its major support from subjacent tissue and throw a

greater percentage of the opposing occlusal thrust on one abutment for the fixed replacement. This would cause leverage or torque which might eventually unseat or loosen the cemented retainer.

Equilibration of the mouth before the construction of a fixed partial denture may include grinding or reshaping occluding cusps or the construction of crowns or splints to level the occluding surface or to move it buccally or lingually. These restorative procedures include some change in cusp form or in cusp position and probably a decrease in the area of the occluding food table.

If teeth approximating the abutments for a fixed partial denture can be restored, there is no rule to say specifically when this must be done, that is, whether before or after the building and cementing of the prosthesis. Orthodontic and surgical correction also may be indicated in mouth preparation.

Removable Partial Dentures.—Mouth preparation for removable partial dentures usually must be much more extensive and complicated. Not only should prophylactic and periodontal treatment be completed, the occlusion equilibrated, and opposing food tables re-established, but also the associated teeth in the arch to be restored may require rebuilding. Using the Kennedy classification for partially edentulous mouths, modification areas should be examined critically to determine the possibility of constructing fixed partial dentures. The life of isolated bicuspids will be prolonged indefinitely if they can be rigidly joined to other teeth.

When properly distributed, healthy abutment teeth are present, modification spaces should be filled with fixed partial dentures, especially in the anterior part of the mouth. This will simplify the design of the removable partial denture, and a more satisfactory and easily obtained path of insertion can be employed. Thus, much of the adverse pressure connected with the insertion and removal of the prosthesis can be eliminated, and better control of leverages and indirect retention can be achieved. Mouth preparation should be planned and executed so that the prosthesis may be inserted and removed without rotation, torque, or unreciprocated pressure on any of the teeth used for support and so that all masticatory pressure on the abutment teeth brought about by the leverage originating at the various fulcrum lines will be parallel to the long axes of the abutment teeth.

Mouth preparation should furnish each clasp and indirect retainer with areas suitable for supporting the denture during mastication, for bilateral bracing, and for retention. The abutment teeth must be prepared and reshaped to accommodate occlusal rest seats, a single reciprocating undercut retentive area, and one or two reciprocating guiding planes which will serve several purposes.

ALTERATION OF TOOTH FORM

Grinding the enamel may be sufficient in mouths in which the caries index is extremely low and the teeth are positioned and shaped so that a nondestructive situation can be produced with only slight modification in form. As a rule, tooth form, tooth position, and the long axis relationship of the teeth designated for abutments and for indirect retainers must be altered so much in the establishment of a path for insertion, guiding planes, retention, and support that partial veneer or full veneer crowns are mandatory.

In form, the prepared or recontoured abutment teeth should accept clasp arms very close to the gingival line so that lateral forces will tend to move the teeth bodily rather than in an arc around the individual center of rotation. During insertion and removal, the reciprocating arm of the clasp should move along a surface parallel to the path of insertion. This will support the tooth against lateral movement while the retentive arm of the clasp is flexing and passing over the height of contour into the retentive undercut, and it will not increase the width of the food table.

When unsupported teeth were moved during the insertion of a partial denture in such a way that the supporting alveolus was damaged, the teeth became loose.

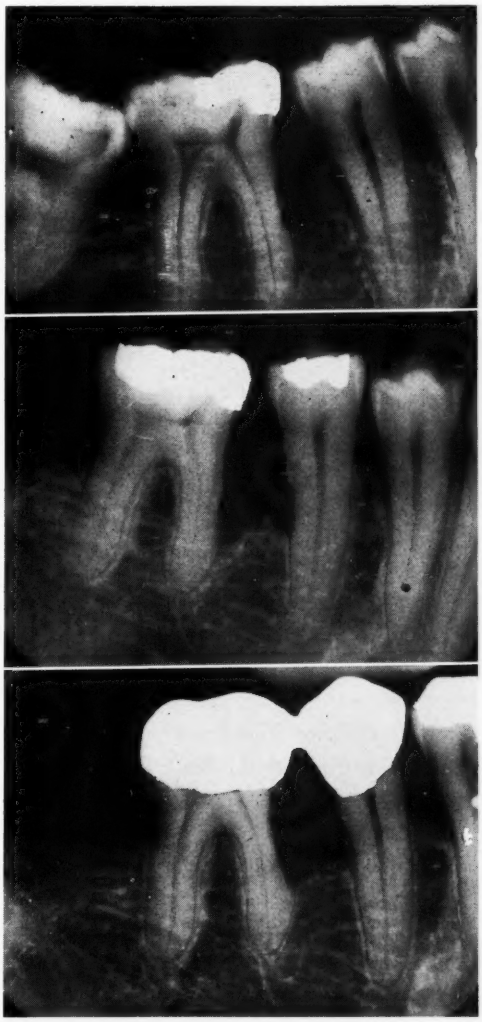


Fig. 2.—The health of teeth is improved by splinting. *A*, The space between the molar and the bicuspid encouraged periodontal disease. *B*, A roentgenogram made 3 years later. *C*, A roentgenogram made 2½ years after the teeth had been splinted together. Note the shape and size of the soldered joint and the improved bone structure.

However, observation and the reconstruction of restorations have demonstrated that when the damaged mouth has been prepared in the manner suggested here, healing has occurred, except when the degeneration had already passed a point of no return.

USE OF CROWNS

Removable partial dentures should be supported and retained by teeth which have been crowned and, very often, splinted. Two relatively weak teeth, when tied together, can make a very strong abutment. I have not observed many patients who have worn partial dentures without damage to the enamel surfaces underneath occlusal rests and clasps. The life of almost every partial denture could be extended, the abutment teeth could be maintained in position more successfully, and the supporting structure would remain healthier if the crowns of the abutment teeth were covered and recontoured to faultless clasp form.

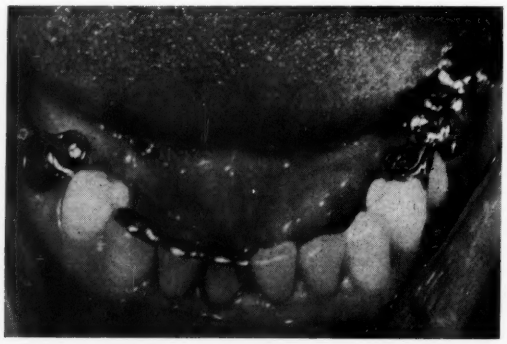


Fig. 3.—The fixed restoration of the lateral incisor allows more freedom in the design of the removable partial denture.

RESTS AND REST SEATS

A rest seat for a clasp or an indirect retainer should be spoon shaped and should angle slightly toward the center of the tooth. It should be of a depth which will allow the occlusal rest to be free from premature occlusal contact and still have strength enough to resist deformation and fracture. The marginal ridge of the rest seat should be lowered to ensure an attachment (between the rest and the minor connector) heavy enough to resist fracture without an excess of gold to interfere with the occlusion. Seldom can it be correctly prepared in the natural tooth structure without cutting through the enamel and making the tooth more susceptible to caries. A rest seat should always be prepared in gold, never in amalgam, because of the tendency of amalgam to wear and flow under pressure and to adversely affect the structure of the metal in the casting of the partial denture.

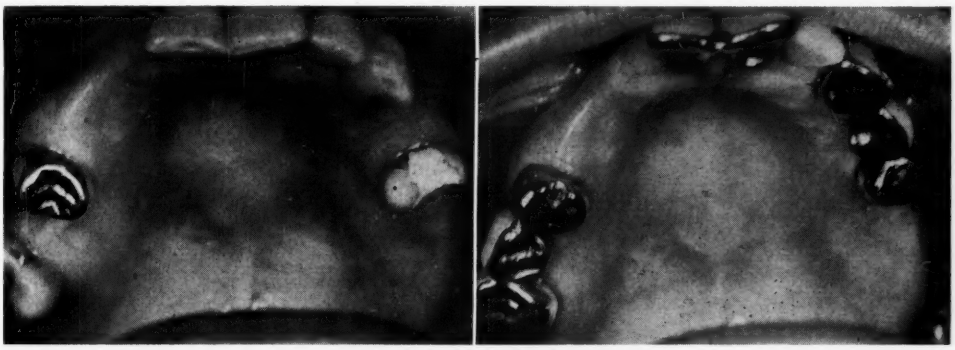
GUIDING PLANES

Guiding planes should be prepared on all tooth surfaces which will contact minor connectors and reciprocal clasp arms. On approximal surfaces, they should

be parallel to the path of insertion or should converge 2 to 5 degrees occlusally to avoid any leverage during mastication. The surface under a reciprocal clasp arm should be formed parallel to the path of insertion so that support is given to the tooth during any period of flexing in the retentive arm. However, in that part of the surface under the tip of the nonretentive arm, there should be some occlusal convergence so that the clasp tip does not bind during movement of the denture base toward the residual ridge.

RETENTION

Retentive undercuts should be located as closely as possible to the gingival tissue, relatively narrow mesiodistally, and only occasionally more than 0.010 inch deep. If the partial denture framework is to be made of chrome-cobalt alloy, the depth of the retentive undercut (with the possible exception of class IV partial dentures) should be reduced from 50 to 75 per cent. When a ring clasp with a con-



A. *B.*

Fig. 4.—Splinted abutments. *A*, The isolated teeth and the unfavorable positions of the abutment teeth in relation to the edentulous areas present special problems. *B*, The abutment teeth are splinted together to form firm abutments for the removable denture.

tinuous arm is used, the depth of the undercut may be safely increased to 0.015 or 0.020 inch. Unfortunately, most removable partial dentures are *overretained.* This is particularly true of the frameworks cast from chrome-cobalt alloys.

CASE HISTORIES

The results of incorrect and correct mouth preparation can be illustrated by case histories.*

Fig. 1 shows a partial denture which had been worn for approximately 8 months by a 23-year-old woman. No rest seats had been cut in the biscuspids or molars. The occlusal rests were placed on the marginal ridges, and this created raised areas which were in traumatic occlusion. The bicuspids were mobile and tender, and the prosthesis was tolerated by the patient only during meals. The roentgenograms (Fig. 1, *A* and *B*) show the damage to the periodontal membranes.

*Restorations constructed or supervised by Drs. D. M. Cunningham, R. W. Dykema, and R. L. Bogen in the dental clinic at Indiana University, School of Dentistry.

Rest seats were made in the bicuspid inlays and the molar crowns which were deep enough to provide sufficient bulk of metal in the rests and to make it possible for the rests to conform to the occlusion (Fig. 1, *D*).

The roentgenograms in Fig. 1, *E* and *F*, were made 6 months after the new partial denture was seated. Healing was in progress, and there was no mobility or tenderness of the teeth. The new prosthesis has been worn for 5 years, and the mouth is healthy and comfortable.

Fig. 2 illustrates the effectiveness of splinting separated abutments. Just after the roentgenogram in Fig. 2, *B*, was made, gingivectomy and alveoloplasty were carried out. After healing, the molar and bicuspid were splinted (Fig. 2, *C*). A clasp-retained partial denture was inserted; it has been worn comfortably since that time. The embrasure form is good and hygiene can be maintained. Oral examination indicates that the region is healthy.

The elimination of "modification areas" is always desirable, especially in the anterior part of the mouth. Greater freedom in selecting the path of insertion is allowed and, frequently, better incision and stabilization of the abutments are provided without including as many teeth as would be necessary otherwise (Fig. 3).

Two posterior modification spaces were restored with fixed partial dentures (Fig. 4). At the same time, two isolated bicuspids, which are always poor risks in partial denture construction, were splinted to other teeth to increase their stability and length of service. The central incisors were splinted together and recontoured to support the anterior base of the partial denture during incision and mastication. The preparation of this mouth changed it from class II, modification III, to class II, modification I. This resulted in a much less complicated design of the removable denture and greater stability of the abutments.

SUMMARY

Mouth preparation includes all operations which re-establish or maintain the health of the abutment teeth, supporting structures, and ridge tissues and which make possible a more simple design for the prosthesis.

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FIXED PARTIAL DENTURES

OBJECTIVES OF A FIXED PARTIAL DENTURE

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IN DISCUSSING THE PLANNING of fixed partial dentures, the objectives desired in performance of this service should first be considered. As in all dental restorative procedures, the essential objectives in replacing missing units are the re-establishment and maintenance of oral function, health, and esthetic appearance. A necessary prerequisite to this procedure is that the existing teeth and tissues be restored to a state of health as favorable as possible.

A fixed partial denture should include the following desirable features if it is to be considered successful: (1) it must be biologically acceptable to oral tissues, (2) it must be fabricated of materials which are compatible with the surrounding structures, (3) its anatomic contours should contribute to oral health by permitting and promoting proper hygiene, (4) its contours should also contribute to the esthetic appearance by harmonizing with the remaining teeth as well as with the facial characteristics, (5) the resultant occlusion should supplement and complement the existing dentition and should be harmonious with the existing mandibular function, and (6) the occlusal surfaces should be shaped and proportioned so that overloading of abutment teeth is avoided.

Since the restoration under consideration will be completely tooth borne, its ultimate success is dependent upon an adequate and healthy periodontium. Every effort must be made to assure at the time of insertion that adequate periodontal support will be available and that it will be maintained. All of this should be done in a manner that is economically feasible for both the patient and the dentist. The patient's attitude, occupational requirements, personal preference, and economic status should be ascertained and, after evaluation, be woven into the plan. The ideal and perfection should be the goal, but they are not always practicable. Compromises must be recognized, evaluated, and made where necessary, but the over-all concern must be to give the patient the best possible restoration that will meet these objectives.

The startling advances of our day are reflected in the rapidly developing knowledge, skills, and tools of our profession. One hesitates to be positive and

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Read before the Centennial Session of the American Dental Association in New York, N. Y.
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cannot be dogmatic in statements, because experience shows that what is widely used today may be obsolescent tomorrow. Much of our practice has been and will continue to be altered by research. What was difficult yesterday may be easy tomorrow. We must meet the challenge by keeping abreast of recent developments, evaluating our abilities, and intelligently making our compromises in order to render services that approach our ideals. When that service is a fixed partial denture, success will be dependent upon planning.

It is not the purpose of this paper to present and explain favorite techniques or devices but rather to set forth such fundamentals as may be used for a guide in choosing such techniques and devices.

GENERAL CONSIDERATIONS IN PLANNING

A complete clinical and roentgenographic examination of the mouth, gums, and teeth is a fundamental prerequisite. This should be followed by prophylaxis, pulp testing of doubtful and abutment teeth, excavation of caries from decayed teeth, removal of indicated teeth, and completion of necessary oral surgical and periodontal therapy. Diagnostic casts should be made, mounted, and studied to gather data which will contribute to the final evaluation and diagnosis.

The prosthodontist, as he examines the patient and finds some teeth missing, naturally asks himself whether a fixed or removable partial denture will serve best. The answer is based partially on the teeth that are missing and those that are present.[1] A fixed partial denture is preferable to a removable denture whenever feasible, but if a removable partial denture is necessary, it may be made less complicated, more comfortable, and more efficient by restoring some of the missing teeth with a fixed partial denture or dentures and then constructing a simplified removable partial denture to replace the missing teeth that could not be replaced with a fixed restoration.

ABUTMENT TEETH

A fixed partial denture normally requires abutment teeth at both ends of the span. Where single teeth are to be replaced, there are occasional situations where a cantilever type of restoration may be used, e.g., a lateral incisor pontic may be supported by a single cuspid, or if multiple splint abutments have been used, they may be sufficient to support a bicuspid pontic without the additional aid of a tooth on the opposite side of the space.

The condition of abutment teeth will affect the plan for the partial denture. The structure of the crown will determine to some degree the choice of the retainer. The root structure and periodontium will determine the degree of support that the abutment tooth can yield. A long, massive root is more favorable than a short, tapered root. A tooth that has a long clinical root with a short clinical crown is superior as an abutment to a tooth with a short clinical root and a long clinical crown. A multiple root tooth is favored over a single root tooth. A malpositioned tooth presents unfavorable abutment qualities because of its angulation and the unfavorable stresses that will be created upon it. In general, an arbitrary rule that the occlusal load placed upon the abutment teeth should not be more than twice

that normally carried by the available periodontal membrane area has proved quite useful. For example, if a second bicuspid has a 150 sq. mm. area of periodontal membrane, a first molar 250 sq. mm., and a second molar 200 sq. mm., the total periodontal membrane area of the three teeth would be 600 sq. mm. If the first molar were lost and the rule were applied, the abutments would have a carrying capacity of twice 150 and 200 sq. mm., or 700 sq. mm. of periodontal membrane area —more than sufficient to replace the 600 sq. mm. On the other hand, if the teeth were periodontally involved, the supporting periodontal membrane might be reduced to 100 and 150 sq. mm., respectively. Then, if the rule were applied, the teeth would have only a 500 sq. mm. carrying capacity—hardly equal to the 600 sq. mm. periodontal membrane area demand. To meet this situation of an unfavorable clinical crown-root ratio, the occlusal load should be reduced either by greatly reducing the occlusal surfaces or by including more support by use of splinted abutments. No practical means is available to accurately measure the available periodontal membrane area of a given tooth in the mouth; however, by combining the evidence visible in roentgenograms with the clinical examination for clinical crown-root ratio and mobility, one can with a few mental gymnastics estimate the relative ratio of available periodontal membrane support to occlusal load. As a general rule, it is safer to err on the side of maximal rather than minimal support.

RETAINERS

In the choice of retainers for fixed partial dentures, the factors to be considered are (1) the preservation of the pulp and health of the abutment teeth, (2) the demands of occlusion, (3) the stress created upon each retainer by other units of the fixed denture, (4) their retentive ability, (5) the general caries index, (6) esthetic appearance, and (7) the probability of expeditious completion of the restoration within the limitations presented by the patient and the dentist.

There are a number of conditions that will determine the choice of retainer. If the tooth is badly broken down by the ravages of caries, it may be possible to restore it only by means of a full crown. If the crown of the tooth is sound, a choice of either an internal or external form of retainer is possible. If the alignment of the tooth is satisfactory and if its occlusal relation is desirable, an internal retainer may be advisable. If the alignment is satisfactory but the occlusal relation is undesirable, a combination internal and external retainer such as an MOD inlay with shoed cusps may serve adequately. If alignment and occlusion are both unsatisfactory, the full crown may be the only satisfactory retainer capable of correcting and compensating for all conditions.

Inlays as Abutments.—When an internal retainer is used, reliance is placed upon the resistance of the abutment tooth to fracture. The cusps of a bicuspid that contains an inlay are subject to stresses that tend to split the tooth apart when lateral or vertical stresses are applied to a pontic fixed to the inlay. Satisfactory inlays call for cutting into teeth to a depth and breadth sufficient to provide a bulk of metal that will assure sufficient strength to resist the stresses placed upon them by an attached pontic. These considerations limit the use of inlays to relatively short spans or to the bearing component of stress-broken joints that support a

pontic. The more bulk that the inlay has, the more strength it has, but by the same token, the tooth has been weakened by the correspondingly increased amount of tooth structure removed. There is a conflict of purpose that must be carefully controlled by the dentist. Much ingenuity has been used in improving the retentive qualities of internal retainers by the use of accurately fitting pins in strategic positions. Their use requires a nicety of execution and skill not developed by the majority of dentists. The internal retainer, judiciously used and exquisitely fashioned, provides a means of retention with a minimum of surface involvement of the abutment tooth and the minimum impairment of its appearance.

Crowns as Abutments.—The external retainer, in the form of the full crown, surrounds the coronal portion of the tooth and binds together the remaining tooth structure, thereby obtaining maximal retention and strength. The length of margin is minimal, and although the total amount of tooth surface removed is great, the depth of cutting and encroachment upon the pulp usually is not as extreme as with the internal type of retainer. The full crown provides the opportunity to meet satisfactorily the requisites of harmonious contours and occlusal design compatible with the stress-bearing ability of the root and proper occlusal function.

The full gold crown, although it is the least esthetic of all retainers, may be used on teeth that are not visible in normal and habitual openings of the mouth. This will vary greatly from one individual to another. Where it is inadvisable to use a full gold crown because of unesthetic display of gold, an acrylic resin or porcelain veneer may be used on it to produce an esthetic result. The veneer requires considerable thickness to obtain sufficient bulk to permit matching of color and to hide the underlying metal. A serious problem is presented by the necessity of removing sufficient tooth structure to permit thickness of the veneering material over the metal without encroaching on the pulp and to avoid an overcontoured crown.

Facings.—Acrylic resin facings are less difficult to fabricate but are susceptible to abrasion. They permit a satisfactory esthetic result when first placed, but if abrasion occurs, they lose much of their surface detail. Porcelain veneers have a durable surface and lend themselves to refinements of color shading and translucency. Retention of a porcelain facing is a problem which may be met in various ways. Platinum pins may be fused in the porcelain facing and cemented in the gold casting. Reverse pins may be cast with the crown to fit into holes ground in the facings. Soft gold tabs may be soldered to the casting at the margin of the recess accommodating the facing and may be burnished to overlap the facing during cementation, thus helping to retain the facing. An acrylic resin facing is not as brittle as the porcelain and, therefore, is not as subject to fracture.

Porcelain Fused to Gold.—A recent development is the fusing of porcelain directly upon the gold casting which results in bonding between gold and porcelain. The problem of retention has been overcome, but color has not been perfected. Continued research will probably overcome this difficulty.

Three-Quarter Crowns as Abutments.—The three-quarter crown is a compromise between the inlay and the full crown. It embodies advantages of both and avoids most of their disadvantages. The labial or buccal display of metal can be held to a minimum, and the natural appearance of the tooth may be preserved.

The retentive qualities of the full crown are inherent to a large degree in the three-quarter crown, and the necessity for the deep cutting required by the inlay is minimized. Retention can be increased by forming lateral grooves in positions as near to the labial or buccal surfaces as esthetic appearance will permit, by giving them as great length as possible, and by preparing them with sufficient bulk to provide rigidity in the completed crown. The three-quarter crown should be used only on teeth that present sound labial or buccal surfaces and have sufficient crown bulk to permit retention by means of grooves or pins or a combination of both.

Pinledge Inlays.—A third type of extracoronal retainer is the pinledge inlay, which further reduces the coverage of the tooth by metal and enhances the appearance. It is used more extensively on anterior teeth than on posterior teeth and relies for retention upon close-fitting pins. The amount of tooth structure removed for its preparation is minimal, and if the pins are carefully placed, there is little danger of encroachment upon the pulp.

SPLINTING

When the ability of the single abutment (at either side of the space to be replaced by a fixed partial denture) to support the restoration is questionable, it may be advisable to use two or more adjoining teeth as a multiple abutment instead. This splinting, accomplished by soldering the retainers together, distributes the stresses over more teeth and may serve to prolong the useful life of the restoration. Periodontally involved teeth, that individually are quite mobile, when splinted together become partially immobilized and present a more stable abutment. Teeth in a posterior or anterior segment of the arch when fixed together by splinting are resistant to movement in the mesiodistal direction and support each other in buccolingual or labiolingual movement. When the splinting includes two or three segments of the arch, the assembled unit is resistant to both types of movement and is often surprisingly stable. The "individual" movement of teeth is of little importance. Splinting does not eliminate all movement, but rather it controls joint movement in such a manner as to prevent excessive individual tooth movement. When so kept within bounds, it is physiologic rather than traumatic.

Where restorative procedures which either repair caries or re-establish occlusal relations dictate placement of adjoining crowns in posterior segments, it is better to join the crowns by solder joints than to leave them as individual units. If there is periodontal involvement, the splinting will be beneficial. If no periodontal involvement is present at the time of placement of the prosthesis, it may develop in the future because, in some instances, the individual movement of the teeth permits wear of the gold at the contact area, with subsequent weakening of the contact and its sequelae.

If prematurities of occlusion exist, splinting the crowns would distribute the stresses over the splinted teeth and would reduce the probability of any one tooth bearing all of the trauma. Even if the crowns involved are in perfect occlusal harmony, there is no harmful effect from splinting.

The only harmful effect possible would come from improper form of the soldered connection between the crowns. Observance of proper proximal crown

contour, provision of ample interproximal space, establishment of lingual and buccal embrasures, and formation of anatomic marginal ridges with well-shaped spillways are essential for the health of interproximal gingival tissues wherever crowns are placed, singly or multiply, joined or not. Certainly the fusion of the contact areas by a small amount of solder should not change these relations any more than in the procedure of joining a pontic to a retainer.

Splinted or multiple abutments in fixed partial dentures should be used whenever conditions permit. Unnecessary cutting of sound teeth cannot be condoned, but the preservation of the entire dentition should be the prime consideration in making this decision.

PONTICS

After selection of adequate abutments and retainers, the next stage in the planning for a fixed partial denture is to determine the type and the design of the pontic. The qualities desired in a pontic are that it be compatible with the surrounding tissues and that it be functional, hygienic, durable, and esthetic.

Materials to be compatible with mouth tissues should be inert chemically and nonirritating mechanically. With these objectives in mind, glazed porcelain is the best of present materials, highly polished gold alloy next in preference, and acrylic resin the least desirable material of the three. Sordes and calculus do not adhere to highly glazed porcelain to the extent that they do to metal or acrylic resin. The hygroscopic nature of acrylic resin permits absorption of mouth fluids into the material, indicated by the foul odor emitted upon grinding acrylic resin after it is removed from the mouth. The odor is different from that obtained in grinding acrylic resin that has not been contaminated by mouth fluids. Whether this absorption of mouth fluid is of pathologic significance is a point that merits investigation. Acrylic resin, when acceptably fabricated, thus far has not evidenced determinable harmful results for which its use might be condemned.

To be functional, a pontic must be constructed of materials that will withstand the stresses of mastication and be in a form that is in harmony with occlusal function, hygiene, and esthetic appearance. Gold alloys meet the requirements of strength and resistance to wear to a greater degree than either porcelain or acrylic resin but fall far short in esthetic value. A combination of porcelain or acrylic resin with the gold alloy becomes necessary when esthetic appearance is important. The occlusal surface reproduced in metal and the visible labial or buccal surface of the pontic in porcelain or acrylic resin meet requirements most effectively. The metallic portion must be of sufficient bulk and strength to withstand independently the forces of all stresses placed upon the restoration. The porcelain or acrylic resin must be so fashioned as to mask the metal and have sufficient strength to remain adherent to the metal.

Hygienic Form.—To be hygienic, a pontic constructed of compatible materials should have a form that will be easily cleansed and which will not induce retention of food particles and debris. In general, its surfaces should be convex, because such convexity is more easily cleansed than a concavity. This is particularly true of the surface of the pontic which contacts the mucosa covering the alveolar ridge. The

extent of contact between the pontic and the alveolar ridge should be as limited as possible. The smaller the contact area, the less likely the pontic is to be irritating and thus cause desquamation or proliferation of the mucous membrane. Minimal pontic contact permits optimal approach for cleansing of the pontic and stimulation of the mucosa. This may result in a deviation from the normal contour and alignment of the replacement, creating a labial or buccal depression at the gingival end of the pontic which would be unesthetic and would produce a possible food trap. A food trap might also be formed on the lingual side of the pontic. A compromise is necessary in which the relative importance of the disadvantage of a broadened contact between the pontic tip and the tissues must be weighed against esthetic appearance and a possible food trap.

Esthetic Appearance.—To be esthetic, a pontic must duplicate as nearly as possible the natural tooth that it replaces. Anatomic form and color are the essence of this quality. Of the two, form is the more important. A replacement tooth with its contour, shape, position, and size harmonious with the rest of the mouth can have a slight variation in color and still produce a pleasant, unobtrusive appearance. A pontic that matches perfectly in color with other teeth may be very conspicuous because of a form that is foreign and unnatural. Observance of the dental anatomic arrangement characteristic to the mouth is of major importance to esthetic appearance. Porcelain, skillfully fabricated, can duplicate the tooth most naturally through shading, the blending of colors, and the blending of opaque and translucent porcelains. Its resistance to wear and its permanency of color are distinct advantages. Acrylic resin may be fabricated more readily, but it does not permit such precise control of color and light refraction. Being a newer material, acrylic resin is in the stage of development and is constantly being improved.

Types of Pontics.—A variety of pontics is available, the most widely used of which are the long pin porcelain facing with built-on porcelain tip and cast gold backing, the Steele facing with a built-up tip and preformed backing to which contour may be added, the Steele facing without a tip and backing, the cast gold pontic with a processed acrylic resin facing with or without a tip, and the all-gold cast pontic. With the porcelain facing and tip, it is paramount that the occlusal surface of the pontic be made of metal of sufficient hardness and bulk to withstand any distortion or deviation in form from occlusal forces that might be applied. If deflections of the backing were possible, the porcelain would not accommodate and would fracture because of its brittleness. This contingency would be avoided in planning the pontic by positioning the facing and beveling the occluding margin to permit adequate bulk of gold in the backing. This problem is not as pertinent when an acrylic resin facing is used, because of the resilient nature of the resin. Flexion of the metal backing under occlusal stress, even though insufficient to cause permanent deformation, might be enough to fracture the porcelain facing but not harm the acrylic resin. As in so many details characteristic of dentistry, the ever-present compromise forces a choice between possible unpleasant display of metal of safe, heavy occlusal protection of the facing and the alternative, more esthetic result with less metallic protection and display but with the possibility of fracture.

Facings.—Where the porcelain facing and tip cannot be used, a porcelain facing with a gold backing may be employed. If the facing is to contact tissue, the

contiguous surface should be glazed. A ground surface of porcelain is irritating to the mucosa and is an ideal surface for calculus to build upon. It would be preferable to cover this ground surface with a polished metal casting which would contact the tissue.

Where acrylic resin is used for a facing, the ridge contact may be either a resin tip or the metal backing. If acrylic resin is used, the contact area should be minimal and it should not press upon the tissue. Where these limitations are observed, the tissues appear to remain healthy; where coverage is excessive and pressure is applied, there is considerable irritation and inflammation around acrylic resin tips. Contact of gold with ridge tissue produces similar results. There is less irritation of mucosa where a smooth convex tip surface is in contact with tissue than where there is a carefully fitted negative reproduction of the underlying tissue, even if the pontic tip is highly polished. The placing of pontic tips against areolar or unattached gingiva almost invariably results in irritation and inflammation. This condition is often seen when the consideration for esthetic results seems to have been predominant.

Gold Pontics.—The all-gold pontic commonly called the "hygienic pontic" is a sturdy, trouble-free pontic that can be used when appearance is not a factor, particularly in lower posterior regions where it is not visible in normal opening of the mouth. The use of a highly polished convex surface out of contact with the ridge permits ease of cleansing and healthy underlying tissues. If space permits, a minimum of 1.5 mm. of clearance over the ridge should be established to discourage possible proliferation of the alveolar mucosa.

ASSEMBLAGE

The joining of the retainers and pontics is the next step in the planning of the fixed partial denture. This is achieved either by soldering together all components, resulting in fixation, or by a combination of fixation and stress breaking. The latter is accomplished by using various forms of rests or interlocking attachments.

This presents the question of whether complete rigidity or individual movement is desired. Fixation is beneficial in most cases and contributes to the success of the restoration. There are instances when complete fixation is not possible or advisable and when it is preferable to employ some means of stress breaking. When there is a great discrepancy in the retentive qualities of the retainers, it is often advisable to break the stress by using a rest on the weaker of the retainers. An example would be where an MOD inlay in an upper first molar and a DO inlay in an upper first bicuspid are to serve as retainers for a prosthesis replacing the second bicuspid. Complete fixation might well result in a loosening of the bicuspid retainer because of the great discrepancy in retentive powers of the two types of inlays. A suitable rest placed in the DO inlay would remove the possibility of this inlay loosening, yet it would provide ample stabilization against any occlusal stresses placed upon the pontic.

Another instance in which a stress breaker fulfills a special need is where the paths of insertion of the retainers cannot be paralleled. A stress breaker placed

in one retainer will permit the placement of that retainer first and the subsequent placement of the remainder of the restoration. This is accomplished by construction of the stress breaker so that its component parts may be joined by insertion in a path parallel to that of the retainer which is fixed to the pontic.

A stress breaker would be expedient where there is an adequate restoration in an abutment tooth. By preparing a suitable seat in the existing restoration, a rest may be used to support the pontic and remaking of the restoration can be avoided.

Requirements of Stress Breakers.—The stress breaker must be planned to meet certain requirements. First, it should withstand the stress and wear caused by function. Stress breakers usually consist of a male part or rest of some form placed in a female part or rest of the corresponding negative form. The rest is usually fixed to the pontic, and the rest seat is formed in the retainer. The bulk of the rest should be sufficient to prevent breakage under heavy occlusal forces and to resist wear caused by friction of the two parts during movement. The same is true of the retainer bulk surrounding the rest seat.

The second requirement of a stress breaker is that it maintain proper relation between the pontic and the retainer. Some type of dovetailing should be used to prevent the pontic from drifting away from the retainer. The rest should seat on a surface that will transmit vertical stress into the long axis of the abutment tooth. It should not be placed on a surface that is so inclined as to wedge the rest out of the seat. Resistance to lateral stresses should be met by an adequate laterally stabilizing form of the seat.

A third requirement of a stress breaker is that it should permit sufficient movement of the one part within the other to break stresses. Fortunately, in most instances, the normal discrepancies of technique obviate a special effort in this respect.

Forms of Stress Breakers.—The most common form of stress breaker in use is the simple occlusal dovetail rest formed with a rest seat that has a flat floor parallel to the occlusal plane, vertical side walls, and an internal divergence that resists proximal movement of the rest.

Another form of stress breaker is the precision attachment type with long vertical walls providing maximal lateral stabilization.

A third is the ball and socket type of stress breaker in which the rest is a ball cast into a spherical concavity in the proximal surface of the retainer. This is accomplished by lining the rest chamber with an antiflux that prevents fusion of the metals during casting and can be dissolved out to permit movement of the two parts of the stress breaker.

Solder Joints.—In soldering together the components of the fixed partial denture, the strength and form of the joint are of primary concern. The solder should alloy with the castings and be of sufficient bulk to ensure against breakage. The form of the joint and the proximal contours of the components of the fixed partial denture are of extreme importance and require careful planning. Properly formed interproximal surfaces contribute to the health of the gingival tissues, while improperly formed surfaces induce inflammation and hypertrophy of the gingival tissues and cause ultimate breakdown of the periodontal tissues.

INTERPROXIMAL SPACES AND EMBRASURES

The interproximal space between pontic tip and retainer, or between splinted retainers, should be adequate to permit space for a normal interdental papilla. Where abutments are splinted, the proximal margins of the retainers should be beneath the marginal gingiva and be separated sufficiently to permit space for a normal papilla. If the teeth are too close together to permit this, they should be separated until adequate space has been obtained. Overcontour of the proximal surfaces of retainers should be avoided so as to prevent impingement upon the papilla.

A lingual embrasure should be created, and marginal ridges should be in occlusion with opposing cusps and be broken lingually to produce spillways and escapements. The buccal embrasure should be anatomic in form to permit cleansing and normal approach to the interproximal space. This composite reduces occlusal stress and permits functional stimulation of the interproximal gingivae.

The opposing surfaces between retainers or between retainers and the pontic before soldering should present normal anatomic contours and contacts so that, in the soldering operation, the solder will flow in and fuse the contact areas. Enough solder should be used to flow around and through the contact area in order to build out into the embrasures to provide sufficient cross sectional strength. This will fill in the interproximal space so that the circumferences of the joint may be blended into the proximal surfaces and be polished, thus presenting a surface that will permit good oral hygiene.

CONCLUSIONS

Having evaluated the individual components of the fixed partial denture and its relation to mouth rehabilitation, the final step in planning is the integration of these components or parts into a whole. Each may be individually suitable, but when assembled they may cause incompatibilities that must be compromised. One retainer that is suitable for its abutment tooth may not be compatible with the retainer that is suitable for the other abutment. One retainer might be an MOD inlay while the other would have to be a full crown. Dissimilar retainers for a fixed partial denture might result in one failing sooner than the other, whereas similar retainers would most likely have equal chance of survival. The resolution of the choice would be the selection of retainers of the most suitable and similar type.

Many situations permit the selection of any of the pontic types available, but certain conditions may restrict the choice in others. Limited space between the alveolar ridge and the opposing occlusion may eliminate the possibility of using a porcelain tip in any form, thus forcing the use of acrylic resin for the facing and tip. It would seem illogical to complicate the restoration by using porcelain veneers on the abutment crowns when acrylic resin is to be used on the pontic.

The cost of construction may influence the planning of the fixed partial denture. The liberal use of porcelain facings on retainers and pontics might produce the most ideal restorations, but it might lead to an expense beyond the reach of the patient or be beyond the dentist's ability to provide competent service. The susceptibility of

the porcelain to fracture and the risks of extensive repairs might influence both the patient and the dentist to prefer the use of acrylic resin instead. The availability of competent laboratory assistance may influence the selection of materials and type of restorations that may be used. These various factors must be weighed in planning a restoration that will be compatible with sound dental practice and the patient's needs.

SUMMARY

In this discussion, an attempt has been made to point out the objectives of a fixed partial denture. The various components of the fixed partial denture have been discussed and the requirements of each have been analyzed. The desirable qualities of each have been defined and some of the problems encountered have been pointed out. Compromises that are to be expected have been noted, and fundamental principles involved in planning for a biologically acceptable restoration have been discussed. Little attempt has been made to present or recommend techniques or to point out their limitations and the restrictions that they may present.

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ELIMINATING TOOTH GUIDANCE IN NATURAL DENTITIONS

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TWO METHODS have been proposed in the attempt to avoid tooth guidance of mandibular movements. One calls for removal of the cusps, while the other proposes to shape and gear the cusps to fit chewing motions.

Cuspless restorations resemble worn out teeth and have no definite "most closed" centric occlusion. Flat teeth have no definite blade relations as they move into occlusion. They encourage horizontal chewing or raspings which tip the teeth. The sliding friction between two opposing flat teeth is not lessened by narrowing the occlusal table. The friction is only more concentrated per square inch. Flat teeth that deflect the mandible are tipped as positively as if they had cusps.

Cusps are the elements of organized occlusion.[1] Tooth-tipping guidance can be avoided by using cusps that are properly geared to the moving axes of the condyles.

Many dentists have tried to use cusps in a balanced occlusion that requires them. However, a balanced occlusion cannot be achieved if teeth keep the jaw from its most posterior position or guide the jaw. Balanced occlusion is the resultant of the arrangement of teeth. The centric occlusion is modified so that all teeth have even closure contacts when the mandible is in a protrusive position. The occlusion is adapted to allow lateral interdigitation and lateral balancing contacts across the dental arch and is readapted to allow balancing contacts in lateroprotrusive closures. Thus, all closures are interdependent, and each one must be considered and modified, if necessary, to permit all others to take place. The main purpose of developing these closures was an arrangement of teeth that would not guide the jaw, thus allowing the muscles and the joints to control the directions of the chewing movements.

A zone of "near" centric relation closures was provided to avoid interlocking of cusps against the positioning muscles. The central fossae of the molars were flattened and made large enough to permit the opposing cusps to move on level fields. This anatomic condition did not result in a most closed centric relation fit of cusps. Inexact techniques led to this compromise.

HINDRANCES FROM BALANCED OCCLUSION

A natural dentition with balanced occlusion may include no teeth that guide the mandible and yet have features quite as restrictive to chewing freedom. The concept that as many teeth as possible should make occlusal contacts in all possible

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closures is absurd. It is ridiculous to require all teeth to occlude when just two incisors bite off a thin fiber, and it is awkward for teeth on the balancing side to occlude when a thin bolus of food is chewed on the other side. Having the inclines of the buccal cusps of the posterior teeth incising at the same time as the cuspids and incisors is a useless arrangement. Posterior teeth are not prehensile teeth. In a balanced dentition, the buccal cusps may bite the cheeks and the lingual cusps may bite the tongue, thus hindering the free chewing habits of the specialized groupings of teeth. A balanced occlusion is a strange occlusion for a mouth to accept all at once.

HORIZONTAL CHEWING

The dentist makes lateral and protrusive horizontal strokes repeatedly on the articulator to test the balanced occlusion. This procedure has probably induced the belief that chewing strokes are horizontal. Hence, it is imagined that the cusps should provide inclined planes that become ramps of closure. However, if teeth are rubbed in many chewing strokes daily, they wear too much too soon. A person who has to chew with horizontal jaw motions has malocclusion. Worn teeth are in malocclusion. The beginning of wear is evidence of malocclusion. Well-arranged teeth should wear very slowly and last a lifetime.

There is evidence that night grinding (bruxism) causes more wear than eating. Whether night grinding is caused by central nervous system stimuli or environmental arousal, balanced occlusion paves the way for easy horizontal gnashing.

OCCLUSION FOR VERTICAL CHEWING

A good natural occlusion that occurs in about 5 per cent of contemporary children[2] seems suited for natural teeth. Anthropologists report such occlusion in larger percentages in skulls of children of previous centuries. A dentist may find three of four adults with this occlusion who have maintained fully cusped, little-worn teeth even to the age of 65 or 70 years. Such a dentition discourages horizontal occlusal movements and tends to induce vertical chewing.

FEATURES OF NATURALLY OCCLUDED TEETH

Occluded natural dentitions have features that differ widely from bilateral balanced occlusion. The differences are: (1) the vertical arrangement of the teeth allows freedom in cutting, tearing, and chewing foods, (2) the incisors may be put to work while the other teeth idle, (3) the cuspids can tear tough foods with no contact of the other teeth, (4) the chewing teeth may be used on either side while all other teeth are idle, (5) a general closure of teeth occurs only when the jaw is in the middle and most posterior occlusal position, (6) the upper six anterior teeth have contact with the lower eight anterior teeth in the protrusive incisal test position with all other teeth out of occlusion, (7) only the cuspids contact in a simple lateral deflection of the jaw, (8) only the upper and lower cuspids and the lateral incisors have closure contacts in the lateroprotrusive test position, (9) the molars and bicuspids have occlusal contacts only in centric occlusion, (10) unilateral chewing can proceed without interference from the teeth across the dental arches, (11)

each upper lingual cusp is loosely contained in a fossa of its counterpart in the lower arch, (12) each lower buccal cusp is capped by a fossa of its mate in the upper arch, (13) the upper buccal marginal and lower lingual marginal ridges of the molars and bicuspids have no occlusal contacts anywhere at any time, and (14) a definite centric occlusion does not permit sliding and it coincides with centric relation. The occluding cusps of such a centric occlusion do not stand on mounds, slopes, or flat planes, but in depressions. The mandible should be at its most retruded, middle, and upper position in centric closure. This mandibular position may be called "summit closure," because all major principles of occlusion are satisfied.

DERIVED NATURAL OCCLUSION

The beginning student of occlusion might assume that this natural occlusion is simple and easy to establish. True, it exists as an actual occlusion only in centric occlusion, since the eccentric closures allow contacts of the front teeth and not the molars and bicuspids. Nevertheless, it is a systemically derived occlusion. Each inclined plane, cusp tip, ridge, and fossa bears a precise relation to the basic border movements of the jaw. The graduated heights of the cusps are determined by the protrusive movements and the overlapping of the incisors. The cusp tips are located so they will not strike each other in basic border jaw motions, yet their ridges interpass closely. The blade edges of the buccal cusps do not intermesh but narrowly miss each other in passing. The tips of the occluding cusps pass in and out of fossae without being struck. Even the several small areas on the sides of each cusp that contact the brim of the receiving fossa are not sliding but static surfaces.

As this occlusion is created in wax, the directions of the central, transverse, and oblique grooves of the molars and bicuspids are planned so that in chewing the cusps will not make groove contacts in eccentric positions. The valleys should not be eroded by the incoming cusps, neither should their sides wear away the cusps.

CUSPID RELATIONS

Each upper cuspid should extend slightly below the level of the incisal edge of the incisors and the buccal cusps of the bicuspids. In the pure protrusive test movement, the cuspid may touch gently the rounded buccal surface of the lower first bicuspid. The mesial half of the lingual surface of the upper cuspid should be concave and bear no relationship to the convex shapes of the lingual surfaces of the posterior buccal cusps. By this concavity, the upper cuspid avoids being a jaw guider in cyclic chewing. The upper cuspid should be positioned so that it does not confine the chewing cycle outline of the tip of the lower cuspid. Also, the upper cuspid should not be so lateral as to permit the other cusps to enmesh in extracyclic positions. The upper cuspid should be the only upper tooth to have contact with a lower tooth in the lateral eccentric test positions.

The amount that the cuspids in such pure lateral excursions may separate the bicuspids and molars from occlusion depends upon (1) their intercuspation in centric occlusion and (2) the amount of upper cuspid extrusion. A mesial position of the lower cuspid in centric occlusion might permit the upper cuspid to pass laterally through the occlusal embrasure in lateral movements. In this excursion, little

or no descent of the lower cuspid would occur, hence, little or no occlusal separation of the posterior teeth. A tooth to tooth relation of the cuspids causes more descent of the lower cuspid with the same amount of upper cuspid extrusion because the two teeth are end to end in the lateral closure. The mean position between these two extremes forms a more favorable cuspid relation. For cuspids to have safe relations in extracyclic (eccentric) positions, they should be in good position in the dental arch and be in correct centric occlusion. The unpleasant, truncated wear of cuspids occurring before other teeth are worn indicates that one or all three of these principles are violated. The cuspids are worn off because they guide the jaw.

INCISOR RELATIONS

Incisor relations as measured by vertical and horizontal overlapping are as important to the protection of the molars and premolars as are cuspid relations. The cuspids guard the posterior teeth in the lateral movements. The incisors guard the posterior teeth and cuspids in protrusive extracyclic movements.

The overlapping varies from an insufficient amount, as in an open anterior occlusion, to an excess amount with which the lower incisors strike the palate and the upper incisors strike the lower labial gingivae. If the incisors have end to end occlusion, they invite their own wear and also molar erosion, because they are not free to be used apart from the molars. The incisors may be rasped in each lateral chewing stroke, and they do not have good prehensile capacity.

The best amount of incisor overlap cannot be stated in millimeters or in a fraction of the crown length. Too many factors must be considered, such as the slant of the occlusal plane, the steepness of the eminences, the interocclusal distance between the molars when the front teeth are in incising contacts, and the space between the upper and lower incisors when the cuspids are in tearing positions.

The incisor problem can be summarized. In gaining incisor relations, the centric, lateral, protrusive, and lateroprotrusive movements of the patient must be considered. In the pure protrusive extracyclic position, the incisors should protect the molars, premolars, and cuspids. In the lateroprotrusive extracyclic positions, the incisors are protected from lateral excursions by the cuspids. In centric closure, the incisors are protected by the molars and premolars. This mutual protection cannot be provided in balanced occlusion.

TRADITIONAL THINKING

It has been traditional to believe that teeth should guide the occlusal movements of the jaw. The muscles, it was believed, could move the open jaw about grossly, but only occluding teeth can make its movements exact. The resulting wearing off of the cusps and, later, most of the occlusal enamel was considered good.

Certain theories hold that the health of the periodontium depends upon crown wear. It is said that teeth must wear off to allow the roots to erupt as they add cementum or the pericementum will become pinched. This theory disregards bone adjustment to intrusive forces. The wear, it is claimed, must be made by grinding strokes to induce bone deposition that better prepares the ridges for dentures. From

such dire instruction one might deduce that nothing should be done to noncarious worn teeth except to keep them clean and promote further wear by balancing and narrowing them with stones.

Dentists want patients to keep their natural teeth intact as long as possible. They do all they can to prevent wear. Much of the premature wear results from teeth acting as jaw guiders.

EVILS OF TOOTH GUIDANCE

The evils of tooth guidance were first noticed in young people with dentitions in which the lower incisors close in front of the upper incisors to effect a forward closure. Dentists noted how soon such deflected teeth show wear and how mobile they may become. Lower incisors are poorly anchored to endure such abuse because they stand in the thinnest part of the alveolar process. When they are tipped forward, the part of their roots with the smaller diameter presses forward against the labial cortical plate.

As dentists discovered other teeth that deflected jaw closures, they suspected that they too would have crown and anchorage injuries. However, the forward tipping forces push the flat surfaces of the roots of posterior teeth anteriorly against bone between the cortical plates. It is only when the tipping force is exerted laterally on posterior teeth that the section with the smaller diameter of the roots is pushed against the buccal cortical plates. In the well-maintained mouth of a healthy patient, malguidance of jaw movements results chiefly in unesthetic facets. Certain observers looking at the dense bone surrounding the worn off teeth mistake this compensation of health as a benefit derived from tooth destruction.

Tooth guidance becomes complicated when cross dental arch conflicts arise. For instance, a patient may not be able to bite at the left corner of the mouth because the right distal molars are in supraocclusion. Or, molars that should be balancing may contact so hard that molars on the working side cannot function. Such guidances create cross arch leverages. These fulcrums cause muscular confusion and muscular and joint pains, limit the freedom of the muscles in using the teeth sectionally, or require too much condyle-eminence accommodation.

SUMMARY

Natural teeth are tools of the jaw and should not be guides to steer and position the mandible. Natural teeth should not govern the closing direction of the jaw mechanically or neuromuscularly, neither should they determine the horizontal occlusal position of the mandible.

Ideally, full occlusion of natural teeth should occur only when the mandible is in its most posterior, middle, and upper position. Any other occlusal contacts of opposing teeth are relegated to the anterior teeth outside of the chewing cycles. The lateral and protrusive test positions should be made repeatedly during the fashioning of the occlusal surfaces of wax patterns to keep the restorations from becoming guides of the mandible.

The natural teeth should be kept out of balanced occlusion to best preserve the edges of the ridges. The muscles should be free to cause the mandible to utilize the

teeth that are grouped and designed for special tasks. The mandible should be able to use the incisors to incise food without occlusion of other teeth or distant balancing contacts. The mandible should be free to use the corners of the dentition to tear tough foods and to use the buccal sections of the posterior teeth to chew food finely without working any other teeth. No rubbing of the teeth should occur in cyclic chewing. In centric closures (centric occlusion), the contacts should not be sliding ones but dead stops.

The mandible should be in centric relation when the cusps interdigitate. The form of the occlusal surfaces should result from a consideration of the basic eccentric mandibular positions as well as the centric position. Specifically, the shapes and heights of the cusps, their locations, and the grooves between them are all derived partly by examining the eccentric positions to make sure that, in all cyclic chewing movements, there will be no occlusal contacts on the way to the most closed posterior position of the jaw.

The basic principle is the removal of all guidance from the teeth so that they will be passive tools of the muscles operating the mandible about rather exacting mandibular fossae.

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TISSUE RETRACTION FOR FIXED PROSTHESIS

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THE DESIRABLE CHARACTERISTICS of the polysulfide rubber and hydrocolloid impression materials have been shown. These materials are accurate and easy to use and reproduce sharp anatomic detail. Why then do relatively few dentists use them routinely, and why do some begin to use them and stop? Perhaps a complete technique for use of these materials has not been established, or it may be that the method of exposing the gingival margin has not been clearly defined or demonstrated.

TOOTH PREPARATION

The proper planning for exposure of the gingival margin must start with the preparation of the tooth. At first, the preparation is made entirely above the free margin of the gingival tissue (not under it). If possible, a shoulder of 1 mm. is made on the preparation (Fig. 1). The shoulder minimizes tissue abrasion in preparing the tooth and may later be retained, chamfered, or made into a finishing line when the preparation is carried into the gingival sulcus.

An end-cutting bur is used to carry the shoulder preparation under the gingival margin. The design of this bur will not cause the tissue to be abraded (Fig. 1).

A tapered diamond stone which has a safe ball end is used to develop a chamfer or a finishing line under the gingival margin (Fig. 2). The ball end diamond stone prevents destruction of the epithelial attachments and does not abrade tissue as would a carbide bur with a side cut. Final adjustment of the finishing line preparation is made with a tapered diamond stone (Fig. 2), and the shoulder is completed with a tapered diamond stone with a noncutting flat end (Fig. 3).

CLASSIFICATION

The most troublesome phase of the technique is the retraction of the tissue around the gingival margins of prepared teeth. The methods are either conservative or radical.

Conservative gingival retraction is any procedure which does not cause sloughing or loss of tissue. These methods may traumatize the tissue, but healing occurs within 24 to 48 hours. The materials used in conservative gingival retraction are (1) alum (saturated solution), (2) racemic epinephrine (8:100), (3) alum and racemic epinephrine in equal parts, (4) tannic acid (20 per cent solution), and (5) zinc chloride (8 per cent solution).

Read before the 10th District Dental Society, Garden City, Long Island, N. Y.

Radical gingival retraction involves destruction or removal of tissue for exposure of the cavity margins by means of a knife, electrical instrument, or chemical agent. The chemical agents used are Monsel's solution (ferric subsulfate) and zinc chloride (40 per cent solution).

PREPARATION OF RETRACTION STRING

The mechanical retraction is obtained by the use of string placed under the gingivae. The string (parcel post twine) may be obtained from a stationery store and should be unsized. Some types of string are sized (starched), and when they are soaked in any solution, the chemical solution is adulterated.

The string is cut into 3 foot lengths and completely soaked for 1 week or longer to allow the solution to penetrate to the inner strands. Then the strings are removed from the solutions (except those soaked in Monsel's solution), allowed to air dry, and placed in dry bottles and labeled. String saturated with Monsel's solution is the only one stored in solution. When any of these strings are used, they are unwound and used as "strands" of string.

CONSERVATIVE CHEMICALLY IMPREGNATED STRINGS

Racemic epinephrine (8:100) (dried string) is the most effective vasoconstrictor. Alum (dried string) is the best of the drying agents.

The alum–racemic epinephrine combination (dried string) is recommended as a replacement for racemic epinephrine string. There is absorption into the general circulation from abraded tissue, and an epinephrine reaction may result when using 8:100 racemic epinephrine. Therefore, it is advisable not to use it for retraction of multiple abutments with much tissue abrasion or when the physical condition of the patient precludes the use of a strong epinephrine solution. The combination dried alum–racemic epinephrine string may be used as a replacement.

A 20 per cent tannic acid dried string may be used as a replacement for racemic epinephrine or alum–racemic epinephrine combination string when there is a desire to entirely eliminate the epinephrine. Although not as effective a hemostatic agent as either of the above, it is recommended for patients with severe cardiac conditions.

Use of an 8 per cent zinc chloride dried string is considered a modified conservative approach, since it may cause slight sloughing if allowed to remain subgingivally too long.

CONSERVATIVE RETRACTION

Apically From the Margin.—Sections 3 inches long are cut from dried impregnated string of either (1) 8:100 racemic epinephrine, (2) alum–racemic epinephrine combination, (3) 20 per cent tannic acid, or (4) 8 per cent zinc chloride composition. Two strands are separated from this multistrand string. A small amount of the solution is placed in a dappen dish, the fingers are moistened with the chemical, and the impregnated strands are tightly twisted. This makes the

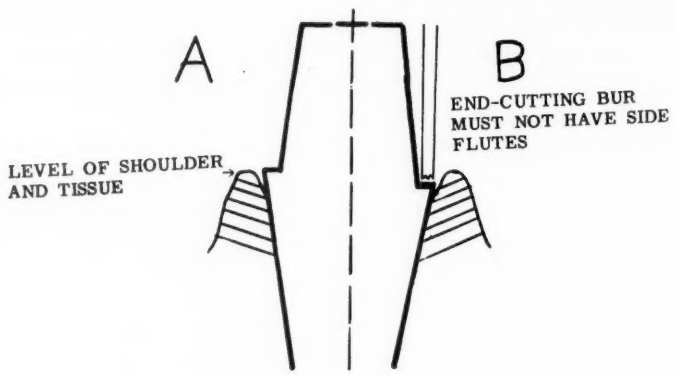

Fig. 1.—*A*, The first stage of the preparation. The shoulder has not been carried below the free margin of the gingival tissue. *B*, Development of a shoulder. The shoulder preparation is carried below the free margin of the gingival tissue.

two strands slightly moist, binds them together more tightly, and thus facilitates their placement under the gingivae. The complete wetting of the strands takes place through seepage from the tissue which redissolves the chemicals and produces the desired concentration of the solution.

The field is air dried as much as possible, and the two slightly moistened strands are "stepped" into the subgingival sulcus below the finishing line or shoulder by means of two double end plastic instruments. One instrument is used to hold the strands in the sulcus beyond the margin of the preparation, while the other instrument is used to place the adjacent part of the strands under the margin by a stepping action (Fig. 4). This prevents the twisted strands from being elevated out of the gingival sulcus. This procedure is repeated until two twisted strands are completely in position (Fig. 5), with a short extension for grasping them for removal.

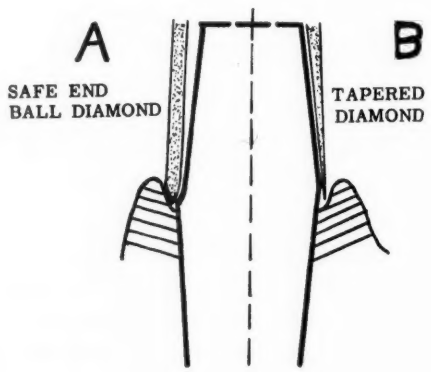

Fig. 2.—*A*, Development of a chamfer. The shoulder is removed with a safe end diamond stone to chamfer the subgingival part of the preparation. *B*, A finishing line is formed in the gingival sulcus with a tapered diamond stone.

Enlargement of the Sulcus.—The compositions used are (1) 8:100 racemic epinephrine, (2) alum–racemic epinephrine combination, and (3) tannic acid. The same type of impregnated string is used to enlarge the sulcus as was used in retraction apically from the margin, except that with zinc chloride any of the other three may be used.

Three to six strands (five were used in Fig. 3) are separated from the 3 inch piece of string and tightly twisted but not moistened. These are stepped into the gingival sulcus apically but not beyond the margins (Fig. 3). The number of strands used depends upon the health of the tissue, i.e., fewer strands are used in young healthy mouths with good epithelial attachments of the tooth in order not to damage these attachments and more strands are used on older individuals with poor epithelial attachments to the prepared teeth. These strands cause deflection of the tissue to allow the placement of the syringe tip close to the margin of the preparation. The strands are left in position for 10 minutes.

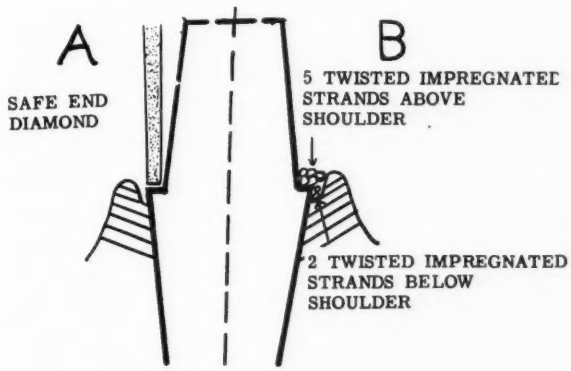

Fig. 3.—*A*, A safe end tapered diamond stone is used to perfect the angle between the shoulder and the remainder of the preparation. *B*, The twisted strands of chemically impregnated strings are shown in position.

Drying the Sulcus.—Alum is used. *Only* the twisted strands (five twisted strands in Fig. 3) that are above the margins are removed, allowing the two twisted strands to remain below the margins. The ones removed are replaced with the same number of twisted impregnated strands of dried alum. The purpose of this step is to facilitate drying. There is no reason to dry these preparations with an air syringe after removing all strands, because the dried alum strands serve as a blotter to absorb the moisture. The strands below and above the margins (Fig. 5) are allowed to remain until the impression material is placed in the syringe and is ready for injecting (Fig. 5). They are then removed (Fig. 6) just prior to the injection.

If there are more than a few preparations, an assistant picks off all strands from one abutment with a pair of serrated tweezers, and the rubber-base material is injected into the gingival sulcus. The same procedure is repeated until all abut-

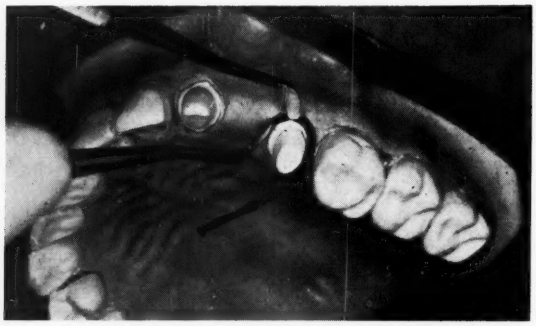

Fig. 4.—Two double end plastic instruments are used to step the twisted strands of chemically impregnated string into the gingival sulcus.

ment teeth are injected and covered with impression material, then the filled tray is placed into position. The reason for this step is that drying with a warm air syringe may cause hemorrhage because of the pressure of the air stream. As careful as one may be in removing the strands, slight bleeding may occur unless the impression material is injected immediately. If bleeding occurs before the viscous rubber-base material contacts the entire preparation, voids will occur in the impression. The blood will not be displaced by the impression material, and the rubber-base material will not be in contact with the preparation. If the tacky, viscous rubber material contacts the entire preparation before any bleeding occurs, the blood cannot displace the rubber material. When the impression is removed after setting, blood may be noted in the impression. The tacky rubber-base material adheres to the tissue and causes bleeding only as it is pulled from the tissue upon removal. Washing the impression shows none of the bubbles or voids that would be present if bleeding had occurred before the material contacted the preparation.

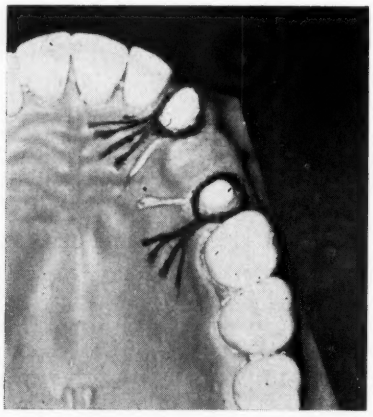

Fig. 5.—The extensions of the strands facilitate their removal from the preparation.

RADICAL CHEMICALLY IMPREGNATED STRING AND RADICAL RETRACTION

Monsel's solution is a styptic rather than a caustic, but it does cause sloughing and is therefore used only for radical treatment. Monsel's string is always used wet, but *all excess solution must be removed* before the string is placed into position. Only two twisted strands of Monsel's string should be used apically from the margin (Fig. 3). The debris resulting from the action of Monsel's solution on blood can be removed with a plastic instrument or cotton and tweezers before the impression is made. Monsel's string is used on posterior teeth to retract tissue in deep pockets when the epithelial attachment of the tooth is absent. As a precaution, the cheek or adjacent buccal or labial tissue is coated with petroleum jelly before placing string saturated with Monsel's solution around the tooth. *Only a dry string saturated with alum is used to enlarge and dry the sulcus.*

String impregnated with 40 per cent zinc chloride (dried) is a radical approach to exposing margins because of its caustic action. Thompson[1] states that cotton strands impregnated with 40 per cent zinc chloride solution are a radical means of tissue retraction, but that they can be used with a minimal loss of epithelial tissue *if applied for only 1 or 2 minutes.*

Petroleum jelly should be used on the adjacent tissue as a precautionary measure. In many instances, it may be necessary to remove the soft tissue from the alveolar bone. This can be done with periodontal knives or 40 per cent zinc chloride–impregnated string. In these situations, the impression must not be made at the same appointment as that at which the preparations are completed. Instead, temporary crowns are placed on the preparations with a temporary cement. The damaged tissue will slough and heal in approximately 1 to 2 weeks, and then the impression can be made, using the conservative retraction techniques.

SUMMARY

A method for the retraction of the soft tissue around the gingival margins of prepared teeth has been described. Until the skill of gingival retraction has been

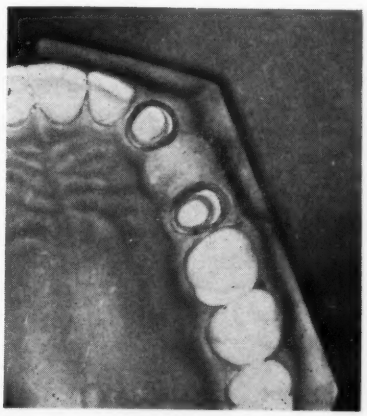

Fig. 6.—All retraction strands are removed prior to making the impression.

mastered, the procedure should be used only for single tooth preparations. The methods described are equally applicable to inlays and to three-quarter and complete crowns.

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FACTORS INFLUENCING THE RETENTION OF CEMENTED GOLD CASTINGS

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THE USE OF CROWNS or fixed partial dentures to restore or replace teeth has gained in importance over the years. With the refinement of chair techniques and improvement in laboratory methods for the fabrication of cast restorations, it becomes increasingly important to understand the functions of retention in cemented tooth castings. On the basis of clinical experience, the factors and properties which *seem* to pertain to and affect retention have been recorded.[1,2,5] However, there has been no yardstick for determining the retentive qualities of a tooth preparation and its casting. Many teeth have been questioned for use as abutments for fixed partial dentures, or subjected to overly complicated procedures, solely on the basis of minimal coronal length and surface area. Accordingly, the loosening of cemented gold castings quite often fails to follow a logical pattern.

FACTORS INFLUENCING RETENTION

For purposes of simplification, the factors which may influence retention have been grouped into those pertaining to three categories: the tooth preparation, the casting, and the cementing medium.

The factors of retention in a prepared tooth are (1) the surface area, (2) the height of the prepared surface, (3) the degree of convergence of the opposing walls of the preparation, (4) the texture of the surface of the prepared area, (5) the intracoronal retentive devices in a preparation, and (6) the degree of retention provided by various components of the prepared area.

The factors of retention in a casting are (1) the relative adaptation of the casting to the prepared tooth surface, (2) the texture of the internal surface of the casting, (3) the effect upon retention of individual castings in a series splinted and cemented simultaneously, and (4) the strength properties of the cast metal required to maintain the cement seal.

The factors of retention that are functions of the cementing medium are (1) the type of cement, (2) the effect of a planned opening in the casting, (3) the in-

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fluence of variations in the viscosity of the cement, (4) variations in the seating force, (5) variations in the duration of the force, (6) variations in the time lapse between the cementing and the unseating procedures, (7) the angle of the unseating force, (8) the magnitude of the lever arm of the unseating force, and (9) the values of the compressive strength and shear strength of various cementing media. In addition, it might be important to consider the pulpal effects of various cementing media, the pH values of various mixes of cement, and the effect on the pulp of the pH and other chemical properties of cements.

To date the following factors have been investigated: (1) the height of the prepared surface, (2) the degree of convergence of the opposing walls of the preparation, (3) the surface area of the preparation, and (4) the effect of a planned opening in the casting.

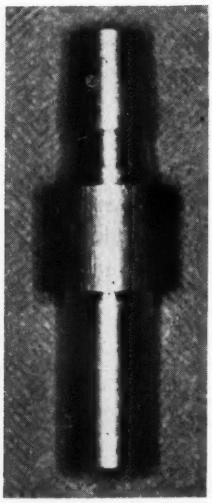


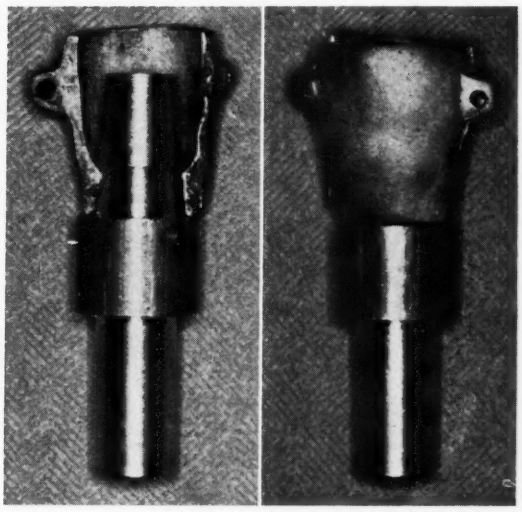
Fig. 1.—A representative test die.

METHOD

It is understandable that forces applied to a casting cemented to a tooth, regardless of the direction of the forces, are partly absorbed by the resiliency of the investing tissues. However, because of the lack of standardization in the mouth, these tests were conducted under a rigidly controlled system using machined dies (Fig. 1).

These dies were made of aluminum alloy of constant resiliency and tensile strength and standardized surface texture. They were lathe turned with a tolerance of 0.001 inch to reproduce typical tooth preparations with predetermined measurements and areas. Only full crown preparations were used. Fig. 1 shows a typical die with the root portion designed to fit into the jaws of a tensile strength–testing apparatus.

Numerous dies were prepared using heights of 4, 7, and 10 mm. with opposing wall convergences of 1, 5, 10, 15, and 20 degrees from parallel for each height.



A. *B.*

Fig. 2.—*A*, A die with a half mold. *B*, Both halves of mold in position.

Various diameters were utilized from 0.175 inch to 0.375 inch at intervals of 0.025 inch. The preparation portion of the dies had a predetermined lathe-turned surface.

Castings for these dies were produced with the use of a controlled series of waxing, investing, and casting methods. A cast mold was made in two sections so that it could be fitted over the preparation with an opening for the entrance of molten wax (Fig. 2).

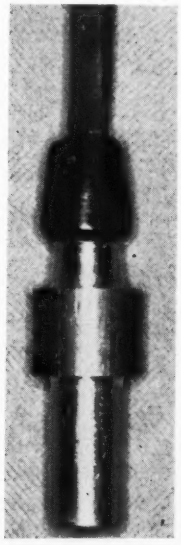


Fig. 3.—A wax pattern and sprue assembly.

TABLE I. UNSEATING FORCES FOR 4, 7, AND 10 MM. DIES WITH CONSTANT 0.250 INCH BASE DIAMETER

HEIGHT (MM.)	CONVERGENCE (DEGREES)	AVERAGE UNSEATING FORCES (POUNDS)					COMPOSITE AVERAGE (POUNDS)	S.E.
		DIE 1	DIE 2	DIE 3	DIE 4	DIE 5		
4	20	25	27	26	23		25	2.0
	15	61	63	58	59		60	3.1
	10	102	99	97	98		99	4.2
	5	143	160	152	153		153	3.8
	1	232	245	247	238		240	3.5
7	20	55	61	58	60	50	55	2.2
	15	93	89	108	100	97	97	3.7
	10	146	148	149	144	145	146	2.6
	5	225	228	227	225	228	227	4.8
	1	400	410	413	403	394	403	6.1
10	15	130	132	132	131	129	131	1.9
	10	205	208	200	208	204	205	3.5
	5	336	326	321	313	304	320	4.7
	1	615	600	600	596	607	604	6.9

Individual molds were made for each of the various die diameters. The dies were lubricated with Microfilm.* Inlay wax, melted and maintained at a temperature of 140° F., was poured into the mold. After the wax had congealed, a weight load of 25 Gm. was applied to the top opening of the mold. The wax was permitted to cool for 10 minutes, and the mold was removed. The pattern thus formed was trimmed with sharp instruments until all the walls had a thickness of approximately 2 mm. A wax rod, rectangular in cross section, was used as the sprue. The cross section was 2 by 4 mm. The sprue was attached to the center of the occlusal surface in line with the path of removal of the wax pattern. This design permitted the sprue portion of the casting to be used as the retaining member in the jaws of the tensile strength tester (Fig. 3).

Investing of the patterns was accomplished immediately after the waxing procedure.[3] The patterns were washed with a surface tension–reducing agent. The casting ring was fully lined with one layer of wet asbestos. A mix of hygroscopic investment was made, and the wax pattern was invested under vacuum. The casting ring was placed in a 100° F. water bath for ½ hour and transferred to an electric burnout furnace which had been preheated to 900° F. It remained in the furnace for 45 minutes at this temperature. Casting was accomplished with a Thermotrol unit.† After the ring had cooled for 5 minutes, it was immersed in a water bath. The crude casting was cleaned with a stiff brush. Only castings that were free of internal defects and that permitted satisfactory seating were used.

The castings were fastened to the dies with a representative zinc phosphate cement.[4] The powder to liquid ratio was controlled by means of a titrometer for

*Kerr Manufacturing Co., Detroit, Mich.
†J. F. Jelenko & Co., Inc., New York, N. Y.

TABLE II. UNSEATING FORCES FOR HEIGHT-CONVERGENCE GROUPS WITH CONSTANT 0.250 INCH BASE DIAMETER

HEIGHT (MM.)	CONVERGENCE (DEGREES)	CONIC AREA* (SQ. IN.)	AVERAGE UNSEATING FORCE (POUNDS)	STRESS—FORCE PER UNIT AREA (P.S.I.)
4	20	0.102	25	245
	15	0.107	60	561
	10	0.111	99	892
	5	0.118	152	1,288
	1	0.123	240	1,951
7	20	0.138	55	398
	15	0.160	97	606
	10	0.177	146	835
	5	0.197	227	1,152
	1	0.212	403	1,901
10	15	0.185	131	708
	10	0.227	205	903
	5	0.271	320	1,181
	1	0.301	604	2,002

*Area of the vertical walls only. Area = ½ (slant length) (base diameter + top diameter).

the liquid and a measured sample of the powder. Mixing was accomplished in 6 minutes. The casting was filled with the cement mixture, seated with finger pressure, and placed into a clamp which exerts a force of 40 pounds. The casting die assembly was removed from the clamp in 10 minutes. The cement was permitted to set for 24 hours prior to the unseating procedures.

The cemented crown and die were inserted in a tensile strength tester with a head speed of ¼ inch per minute. The forces applied were in line with the path of withdrawal of the casting. At the point that the cement bond was broken, a recording of the applied force was made. The castings were recemented a maximum of six times.

INFLUENCE OF VARIATION IN HEIGHT AND CONVERGENCE

In this study, three height variations were used. Dies of 4, 7, and 10 mm. with constant taper were fitted with castings, and the cemented assembly was placed in the tensile strength tester. Table I shows the compiled values of the forces required to unseat the castings.

Analysis of the figures in Table I shows an obvious increase in retentive ability as the height increases. This increase is not uniformly proportional, as can be seen in comparison of the 4 mm., 10 degree convergence die and the 7 mm., 10 degree convergence die. In evaluating the 4 mm., 10 degree die, the average retentive force for each millimeter is approximately 25 pounds. On the other hand, the 7 mm., 10 degree die gives an average height unit retention value of approximately 20 pounds. This is understandable in view of the fact that, in any converging cylinder, with each successive millimeter of height the diameter becomes smaller and there is

a reduction in area. The variation is not evident when the retentive surfaces approach parallelism. This is demonstrated when the 4 mm., 1 degree convergence die with a retentive ability of 240 pounds is compared with the 10 mm., 1 degree convergence die with a retention of 604 pounds. The average unseating force required for each millimeter of height in both cases is similar, approximately 60 pounds. It can be concluded that with a convergent preparation the gingival area contributes the greater retention, in contrast to the more nearly parallel preparation which has more uniform retention throughout its height.

It should be noted in the 4 mm. group of dies that the 1 degree convergence die has almost 10 times the retention of the 20 degree die. In the 7 mm. group, the force increases 8 times when a comparison of the same two convergences is made. This difference is not as great in dies with small differences in convergence. When the convergence changes from 1 to 5 degrees, only 40 per cent of the retention is lost.

The initial cementation for each casting gave the maximum value; the figure decreased with repeated cementations. Further investigation may show that burnishing of the minute undercuts of the internal surface of the casting was responsible for the loss in retention.

Table II shows the unseating force values for each height-convergence group and their relationship to unit surface area. The last column records the stress values, which were computed by dividing the force by the conic area of the die according to the formula $S = F/A$, where F is the unseating force and A is the area of the prepared surface. This formula provides a measure of the retention demonstrated by each unit of surface area. A comparison of the stress values for

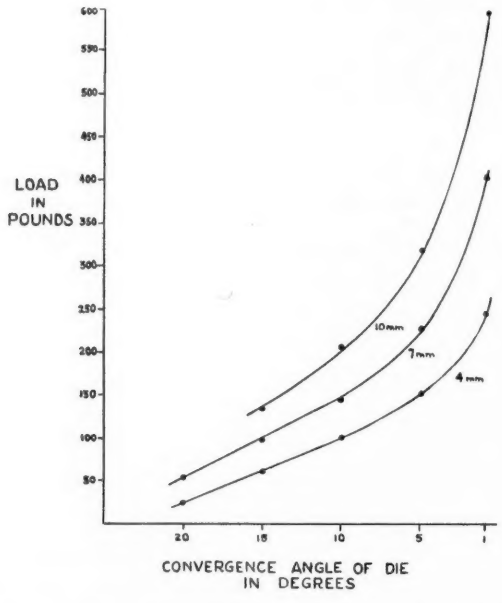


Fig. 4.—Comparison of unseating forces for die groups by various angles of convergence.

a group of dies that have the same degree of convergence shows very consistent values. This occurs in spite of variation in the height of the preparation. It can be concluded that every unit of area on a prepared tooth surface having the same degree of convergence has the same retentiveness, regardless of the height of the

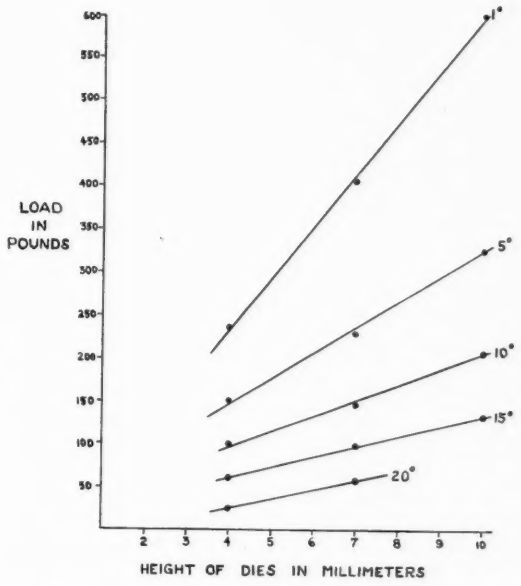


Fig. 5.—Graph comparison of height groups.

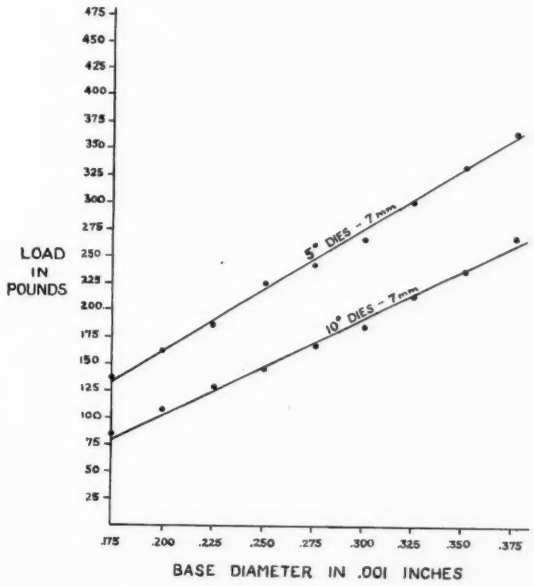


Fig. 6.—Force values for dies of various diameters.

TABLE III. UNSEATING FORCES FOR DIES WITH DIFFERENT DIAMETERS

DIAMETER (IN.)	TOTAL AREA (SQ. IN.)	AVERAGE UNSEATING FORCES (POUNDS)						COMPOSITE AVERAGE (POUNDS)	STRESS (P.S.I.)
		RUN 1	RUN 2	RUN 3	RUN 4	RUN 5	RUN 6		
Constant 7 mm. height and 5 degree convergence									
0.175	0.131	125	140	135	140	145	135	137	1,046
0.200	0.153	170	160	175	150	155	160	162	1,059
0.225	0.175	190	185	175	180	195	180	184	1,052
0.250	0.197	225	220	230	240	215	225	226	1,152
0.275	0.219	230	245	240	250	235	245	241	1,100
0.300	0.241	270	265	255	275	270	265	267	1,108
0.325	0.263	310	305	310	290	285	300	300	1,141
0.350	0.285	350	325	335	325	345	325	334	1,172
0.375	0.307	380	340	360	350	365	375	362	1,180
Constant 7 mm. height and 10 degree convergence									
0.175	0.111	90	95	85	85	90	80	88	793
0.200	0.133	120	110	100	115	110	105	110	827
0.225	0.155	130	135	140	130	120	125	130	839
0.250	0.177	145	140	150	155	140	145	146	835
0.275	0.199	160	155	170	170	175	170	167	839
0.300	0.221	180	175	195	190	185	190	186	842
0.325	0.243	195	215	220	200	210	220	210	864
0.350	0.265	230	240	240	250	235	250	241	909
0.375	0.287	275	275	255	260	265	280	268	934

inclined surface. For example, the 4 mm., 10 degree group of dies shows a stress value of 885 p.s.i., and the 10 mm., 10 degree group exhibits a similar stress value (890 p.s.i.). A comparison of preparations with similar areas (third column) but with variable heights and convergences shows no relationship. The 4 mm., 1 degree group of dies and the 7 mm., 20 degree group have similar total areas, 0.125 sq. inch and 0.138 sq. inch, respectively. In spite of this similarity, the 4 mm., 1 degree preparation exhibits almost 5 times the retentive capacity of the other preparation.

The resistance to unseating a cemented casting increases much more rapidly as the walls of the preparation approach parallelism. On the other hand, the increase in retention is less marked with an increase in height.

Fig. 4 shows a change in retention as the angle of convergence is modified for each height group of dies. The curves are similar, with the most abrupt increase occurring in the 5 degree convergence group. This would appear to confirm the work of Gillette and Irving[5] and of Jørgensen[6] concerning the importance of approaching parallelism between the opposing walls in a prepared tooth. Jørgensen's results compare favorably with the figures obtained in this study in spite of the fact that different materials and techniques were employed.

Fig. 5 shows the variation in retention as the height of the preparation increases and the angle of convergence remains constant. The straight line curve has a greater slope as the convergence angle decreases. Again, the critical nature of the convergence function is apparent. In examining the figures, there is a difference of 30 pounds between the 4 mm., 20 degree die and the 7 mm., 20 degree die, whereas the difference in retention between the 4 mm., 1 degree die and the 7 mm., 1 degree die is 163 pounds.

INFLUENCE OF CHANGE IN DIAMETER

A comparison of the unseating resistance using dies of various diameters demonstrates an anticipated increase which is directly proportional to the increase in unit area at constant convergence. Table III shows the figures obtained as the diameter increases by 0.025 inch increments and the surface area is increased by the necessary 0.22 sq. inch increments. The increase in unseating force between each of the diameters again approximates a constant. Plotting of these values (Fig. 6) shows this linear change. Observe in the graph that a die with a 7 mm. height, a 10 degree convergence, and a base diameter of 0.300 inch has retention similar to a 7 mm., 5 degree die with a 0.225 inch base diameter. The 0.225 inch die has an area similar to that of an upper lateral incisor tooth, and the 0.300 inch die has an area similar to that of an upper bicuspid tooth. It might be considered that the retentive properties of a bicuspid full crown preparation when this method is used are similar to those obtained in an anterior preparation even though there has been a loss of convergence of 5 degrees in the bicuspid. As a further comparison, a 0.375 inch die which is comparable to a small molar and has a 10 degree convergence at a constant height has retention similar to a 0.300 inch die resembling a bicuspid which has 5 degrees less convergence.

TABLE IV. STRESS VALUES FOR DIES WITH DIFFERENT DIMENSIONS

HEIGHT (MM.)	BASE DIAMETER (IN.)	UNSEATING FORCE (POUNDS)	S.E.	STRESS (P.S.I.)
Difference in diameter: Constant 10 degree convergence				
7	0.175	88	4.0	793
	0.200	110	3.9	827
	0.225	130	3.2	839
	0.250	146	2.6	835
	0.275	167	4.1	839
	0.300	186	4.4	842
	0.325	210	3.4	864
	0.350	241	3.2	909
	0.375	268	3.9	934
Difference in diameter: Constant 5 degree convergence				
7	0.175	137	3.3	1,046
	0.200	162	4.2	1,059
	0.225	184	4.1	1,052
	0.250	227	4.8	1,152
	0.275	241	3.9	1,100
	0.300	267	3.4	1,108
	0.325	300	3.6	1,141
	0.350	334	4.2	1,172
	0.375	362	6.5	1,180
Difference in height: Constant 1 degree convergence				
4	0.250	240		1,951
7	0.250	403		1,901
10	0.250	604		2,002

TABLE V. MEASUREMENTS OF CASTING DIE ASSEMBLY BEFORE AND AFTER CEMENTATION; CONSTANT 7 MM. HEIGHT, 5 DEGREE CONVERGENCE, AND 0.250 INCH DIAMETER

DIE NUMBER	MEASUREMENT FROM TOP OF SPRUE TO BASE OF DIE (IN.)		DIFFERENCE (IN.)
	WITHOUT CEMENT	AFTER CEMENTATION	
75	1.835	1.846	0.011
77	1.624	1.636	0.012
92	1.309	1.319	0.010
99	1.867	1.878	0.011
100	1.770	1.783	0.013
104	1.704	1.715	0.011
106	1.791	1.801	0.010
107	1.841	1.853	0.012
108	1.847	1.856	0.009
110	1.923	1.936	0.013
111A	1.555	1.565	0.010
114	1.472	1.482	0.010
101A	1.766	1.777	0.011
101B	1.899	1.909	0.010
102A	1.737	1.748	0.011
102B	1.636	1.650	0.014
102C	1.655	1.664	0.009
103A	1.742	1.753	0.011
103B	1.479	1.490	0.011
103C	1.961	1.971	0.010
Average			0.011

TABLE VI. MEASUREMENT OF OCCLUSAL CEMENT FILM THICKNESS; CONSTANT 7 MM. HEIGHT, 5 DEGREE CONVERGENCE, AND 0.250 INCH DIAMETER

DIE NUMBER	OPTICAL FLATS CALIBRATION*	OCCLUSAL CEMENT ADDED† (IN.)	DIFFERENCE (IN.)
75	0.142	0.153	0.011
77	0.142	0.154	0.012
92	0.142	0.151	0.009
99	0.142	0.151	0.009
100	0.142	0.154	0.012
104	0.142	0.152	0.010
106	0.142	0.152	0.010
107	0.142	0.153	0.011
108	0.142	0.151	0.009
110	0.142	0.155	0.013
111A	0.142	0.152	0.010
114	0.142	0.152	0.010
101A	0.142	0.151	0.009
101B	0.142	0.151	0.009
102A	0.142	0.152	0.010
102B	0.142	0.155	0.013
102C	0.142	0.150	0.008
103A	0.142	0.153	0.011
103B	0.142	0.152	0.010
103C	0.142	0.151	0.009
Average			0.010

*Micrometer reading of the optical flats as a zero reading in inches.
†Measurement of occlusal cement layer removed from casting plus optical flats.

TABLE VII. MEASUREMENTS OF CROWN DIE ASSEMBLY OF PERFORATED AND NONPERFORATED CASTINGS; CONSTANT 7 MM. HEIGHT, 5 DEGREE CONVERGENCE, AND 0.250 INCH DIAMETER

DIE NUMBER	CHANGE AFTER CEMENTATION (IN.)		DIFFERENCE (IN.)
	NO PERFORATION	WITH PERFORATION	
75	0.011	0.004	0.007
77	0.012	0.004	0.008
92	0.010	0.002	0.008
99	0.011	0.003	0.008
100	0.013	0.004	0.009
104	0.011	0.002	0.009
106	0.010	0.002	0.008
107	0.012	0.003	0.009
108	0.009	0.001	0.008
110	0.013	0.004	0.009
111A	0.010	0.003	0.007
114	0.010	0.003	0.007
101A	0.011	0.002	0.009
101B	0.010	0.002	0.008
102A	0.011	0.002	0.009
102B	0.014	0.004	0.010
102C	0.009	0.001	0.008
103A	0.011	0.002	0.009
103B	0.011	0.002	0.009
103C	0.010	0.001	0.009
Average	0.011	0.003	0.008

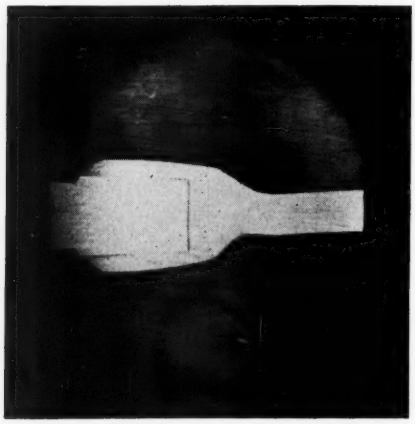


Fig. 7.—A sectioned cemented crown die assembly. Observe the excessive cement layer in the occlusal area. The occlusal line angles of the preparation probably block the escape of cement from this area during the final stages of seating.

TABLE VIII. COMPARISON OF PERFORATED AND NONPERFORATED CASTINGS

CONVERGENCE (DEGREES)	HEIGHT (MM.)	BASE DIAMETER (IN.)	NONPERFORATED CASTING		PERFORATED CASTING		INCREASE (%)
			AVERAGE FORCE (POUNDS)	S.E.	AVERAGE FORCE (POUNDS)	S.E.	
5	7	0.250	227	4.8	299	6.2	32
10	7	0.250	146	2.6	192	3.4	32
15	7	0.250	97	3.7	124	3.2	25

Table IV comprises compilations of readings obtained from dies of variable height and diameter but with constant convergence. Examination of the stress values in each convergence group shows more than a coincidental relationship, despite changes in the height and diameter. The total stress of a given die can be considered to be related primarily to the resistance of the vertical walls. The top area appears to contribute less to the total retention.[7] The deviation between stress values of a convergence group may be partly due to the increase in top or occlusal area as the base diameter increases. In computing a formula for the fundamental retention of a preparation, consideration must be given to other factors such as surface texture and the resistance of the cementing medium. Thus, if $S = F/A$, where S is the stress, F is the unseating force, and A is the total area, $F = SA$. A modification of this formula can be made on the assumption that the predominant resistance occurs on the inclined walls of the preparation. Thus, $F = SA' + K$, where A' is the area of the inclined walls and K is the retention provided by the top area, the surface texture, the resistance of the cement, and other variables.

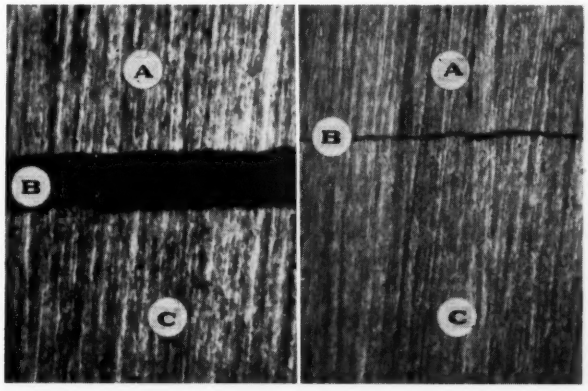
TABLE IX. COMPARISON OF RETENTION OF PERFORATED AND NONPERFORATED CASTINGS WITH DIFFERENT DIAMETERS; CONSTANT 7 MM. HEIGHT AND 5 DEGREE CONVERGENCE

DIAMETER (IN.)	NONPERFORATED CASTING		PERFORATED CASTING		DIFFERENCE (POUNDS)	INCREASE (%)
	AVERAGE FORCE* (POUNDS)	S.E.	AVERAGE FORCE* (POUNDS)	S.E.		
0.175	137	3.3	176	4.7	36	26
0.200	162	4.2	190	4.5	30	19
0.225	184	4.1	228	6.2	46	25
0.250	227	4.8	299	6.2	73	32
0.275	241	3.9	304	6.6	65	27
0.300	267	3.4	340	3.3	78	30
0.325	300	3.6	372	3.2	72	24
0.350	334	4.2	415	4.1	82	25
0.375	362	6.5	447	4.6	84	23

*Average unseating force of twelve tests on the tensile strength–testing apparatus. It is the weight load recorded for these cemented castings.

EFFECT OF A PLANNED OPENING IN THE CASTING

One of the problems encountered in this study was the inability to seat the castings completely during the cementation procedure. The difficulty increased as the walls of the preparation approached parallelism, principally in the 1 degree and 5 degree groups, but was not apparent when the castings were seated without cement. In order to determine the magnitude of this deviation, measurements were made using a technique suggested by Selberg.[8] With the casting seated on its respective die, a measurement was made from the base of the die to the tip of the sprue using a 1 to 2 inch micrometer caliper. This was performed prior to cementa-



A. *B.*

Fig. 8.—Sectioned castings and die assemblies with and without perforations (×30; reduced ⅓). *A*, Without perforation. *B*, With perforation. *(A)* The casting; *(B)* the cement layer; *(C)* the die area.

tion, and a comparison measurement was made after cementation. Table V shows the amount of displacement of the castings as a result of the introduction of cement (Fig. 7).

In order to obtain a specific relationship between the measured displacement of the casting and the thickness of the cement layer in the occlusal area, the casting die assemblies were dismantled and representative sections of the occlusal cement layer were measured using a set of optical flats and a micrometer caliper. Table VI is a tabulation of these measurements. Observe that in comparing Tables V and VI, the casting displacement compares favorably with the cement film thickness of the occlusal area.

Thus, an investigation of the advantage of an escapement for the cement was indicated. For this purpose, castings were waxed with a perforation in the central area of the occlusal surface just adjacent to the sprue and cemented with this perforation alternately opened and closed. During this procedure, the castings seated much more easily when there was an opening present. Apparently this would be of advantage during clinical procedures.

Fig. 8 illustrates the difference in cement film thickness at the occlusal surface when castings are cemented with and without perforations.

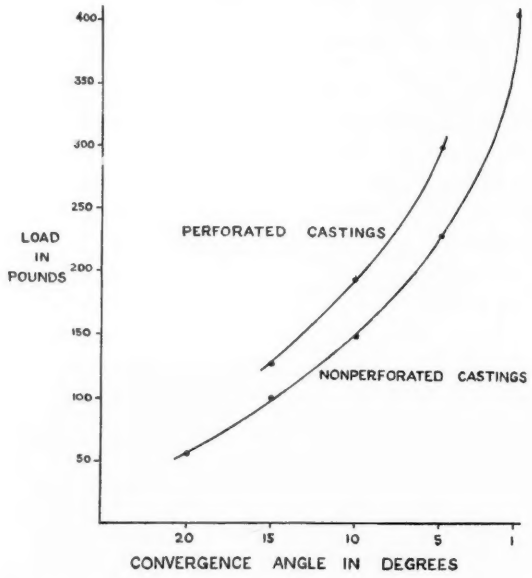


Fig. 9.—Retention curves of perforated and nonperforated castings.

Table VII shows the relative difference in seating ability during cementation between castings with and without occlusal openings.

Analysis of the figures in Table VII shows that in some cases there is a displacement of more than 0.01 inch (equivalent to 0.25 mm.). This emphasizes the importance of a planned opening in the casting for the escape of excessive cement. Assuming that in clinical practice the margin of the casting uncemented would go

to the finishing line of the preparation, the casting without a perforation, when cemented, would leave that amount of prepared tooth structure uncovered.

Further analysis of the differences between castings cemented with and without perforations was made by obtaining the unseating force values for the castings used in Table VII.

Tables VIII and IX show the marked differences in load ability of the same casting perforated and nonperforated. The advantage of the perforation is evident in the last columns of Tables VIII and IX which show the percentage increase in load application. In Figs. 9 and 10, a comparison is made between the retention curves of perforated and nonperforated castings. Observe that there is a consistent increase in retention throughout the range of convergence in Fig. 9 and in the range of diameters in Fig. 10 when the castings are perforated. Assuming that the perforated casting is seating more effectively, the increase in retention may be a result of the improved adaptation of the castings to the preparation surface. A component of this increase may be derived from the actual increase of coverage in the marginal area. It would appear that the routine use of a perforation is indicated if maximal retention and optimal coverage are to be obtained.

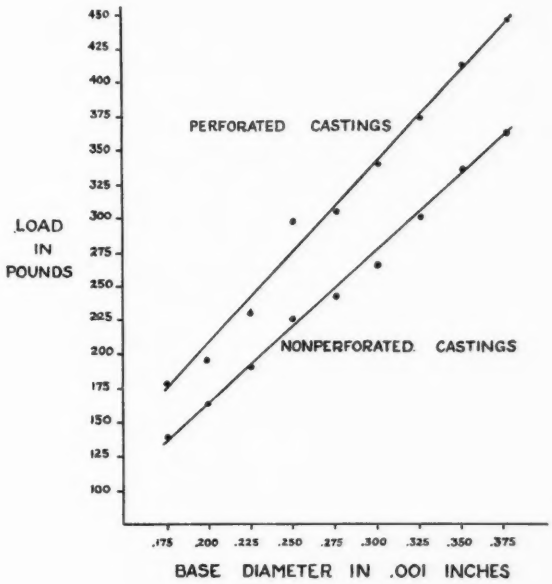


Fig. 10.—Retention curves of perforated and nonperforated castings.

SUMMARY

Studies of some of the factors which influence the retention of cemented gold alloy castings are reported. The tests were made on metal dies with controlled variations in height, angle of convergence, and diameter. Castings were fabricated by use of a controlled technique, and the resultant casting cemented to die assemblies were subjected to unseating forces on a tensile strength–testing apparatus. The

difficulties encountered in seating the casting completely led to a study of the effect of a planned opening in the castings as an escapement for excess cement.

CONCLUSIONS

1. The resistance to unseating a cemented casting in line with the path of insertion increases significantly as the opposing walls of a preparation approach parallelism.

2. The increase in retention is less marked with an increase in height.

3. An analysis of the retention of tooth preparations with the same degree of inclination demonstrates that each unit area of this surface has comparable retentive ability, regardless of the other dimensions of the preparation.

4. There is a linear increase in retention as the preparation increases in diameter.

5. In a convergent preparation, the areas closer to the gingival termination contribute the greater proportion of the retention.

6. Castings do not seat completely during the cementation procedure, and this discrepancy is clinically significant. The intervening cement layer at the occlusal surface is excessive under nonperforated castings, thus violating marginal relationships. This is a more critical problem in preparations the walls of which approximate parallelism and appears to be related to the degree of adaptation of the two parts.

7. The use of a planned occlusal opening for a casting allows more nearly complete seating, greater ease of placement, and an increase in retentive ability of 19 to 32 per cent.

Further studies will evaluate the optimal viscosity of the cementing medium, the advantage of modifying the contour of the occlusal portion of the preparation for more adequate release of cement from this area, and the effect upon retention of a change in surface texture of the preparation and its casting.

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FILLING BASE MATERIALS AND THE UNEXPOSED AND EXPOSED TOOTH PULP

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THE CONTINGENT EFFECT of operative procedures upon the tooth has been studied in the laboratory several times in the past. Most of this research has considered the problem from the standpoint of the effect of the filling materials on the dental pulp.[1] The effect on the pulp of heat generated during the cavity preparation has also been reported.[2] Silicate cement fillings have been held accountable for pulp injury.[3] Recently, acrylic resin filling materials also have been blamed.[4] It has been pointed out that pulp injury is more common in teeth of young individuals in whom pulps are large, thus more vulnerable to exposure and injury from operative procedures and filling materials.[5]

These and many other references seem to indicate that there is more than one cause of pulp injury. This is reasonable because connective tissues such as those found in the pulp are known to respond to mechanical, thermal, bacterial, and chemical irritants. Any one of these factors can be found in either dental caries itself, the mechanics of cavity preparation, or the chemical composition of materials used to restore the tooth. Since there seems to be more than one cause of pulp injury associated with caries and restorative procedures, one cannot help but wonder if it would not be possible that more than one of these causative factors operates through a single common agency.

PURPOSE

It is the purpose of this study to examine histologic sections of the pulps of teeth of dogs 1 week after the insertion in deep cavities of commercial preparations containing, respectively, bases of calcium hydroxide, zinc oxide–eugenol, and oxyphosphate of zinc cement.

From a thesis submitted to the faculty of the Indiana University, Graduate School, in partial fulfillment of the requirements for the degree of Master of Science in Dentistry.

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TABLE I. CUTTING SPEEDS, THICKNESS OF CAVITY FLOOR, AND DEGREE OF PULP INJURY

TOOTH NUMBER	R.P.M.	THICKNESS OF CAVITY FLOOR	CONDITION OF PULP
Calcium hydroxide paste			
1	6,000	0.085 mm.	Normal
2	6,000	0.100 mm.	Normal
3	6,000	0.277 mm.	Normal
4	6,000	0.270 mm.	Normal
5	200,000	0.025 mm.	Reduced odontoblasts
6	200,000	0.130 mm.	Normal
7	6,000	Visible exposure	Dentinoid bridge, no pulpitis
8	6,000	Visible exposure	Laceration, pulpitis
9	200,000	Visible exposure	Laceration, histiocytic infiltration
10	200,000	Visible exposure	Laceration, pulpitis
11	200,000	Visible exposure	Laceration, pulpitis
12	6,000	Visible exposure	Laceration, pulpitis
13	200,000	Visible exposure	Laceration, pulpitis
14	200,000	Visible exposure	Dentinoid bridge
15	6,000	Microscopic exposure	Dentinoid bridge
16	6,000	Microscopic exposure	Focal necrosis
17	200,000	Microscopic exposure	Dentinoid pulp displacement
Zinc oxide–eugenol paste			
1	6,000	0.125 mm.	Reduced odontoblasts
2	6,000	0.045 mm.	Normal
3	6,000	0.169 mm.	Slight histiocytic infiltration
4	6,000	0.090 mm.	Slight histiocytic infiltration
5	6,000	0.085 mm.	Slight histiocytic infiltration
6	200,000	0.090 mm.	Normal pulp
7	200,000	0.150 mm.	Normal pulp
8	200,000	0.225 mm.	Normal pulp
9	200,000	0.230 mm.	Normal pulp
10	200,000	0.220 mm.	Reduced odontoblasts
11	6,000	Visible exposure	Focal necrosis
12	200,000	Visible exposure	Focal necrosis
13	200,000	Visible exposure	Focal necrosis
14	6,000	Visible exposure	Laceration
15	200,000	Visible exposure	Dentinoid bridge, no pulpitis
16	6,000	Microscopic exposure	Focal necrosis
Oxyphosphate of zinc cement			
1	200,000	0.150 mm.	Normal pulp
2	200,000	0.450 mm.	Normal pulp
3	6,000	Visible exposure	Focal necrosis
4	6,000	Visible exposure	Focal necrosis
5	200,000	Visible exposure	Focal necrosis
6	6,000	Microscopic exposure	Focal necrosis
7	6,000	Microscopic exposure	Focal necrosis
8	200,000	Microscopic exposure	Focal necrosis
9	200,000	Microscopic exposure	Focal necrosis

METHODS AND MATERIALS

Twelve dogs with no visible evidence of incisal attrition were utilized. Deep cavities about 1.5 mm. in diameter were prepared on the labial surfaces of the canine teeth as close to the gingival margin as possible (Fig. 1). The cavities were prepared with No. 557 fissure and No. 35 inverted cone carbide steel burs, twenty-three at conventional speed, 6,000 r.p.m., and twenty-one at ultra high speed, 200,000 r.p.m. The cavity floors were considered deep at and beyond the point where the red shadow of the pulp became visible to the eye of the dentist. A water spray coolant was used with the air-driven handpiece. Careful manipulation to avoid heat was the only preventive measure used at conventional speed.

Fig. 1.—The red shadow of the pulp is seen through the deep cavity floor. It illustrates the size, position, and depth of cavities used in this study.

When hemorrhage occurred because of pulp exposure, the bleeding was carefully controlled with normal saline solution. All cavity floors including the pulp exposures were kept moistened with saline solution between the time the preparations were finished and the time the base materials were applied. The cavities were dried with cotton pellets just before they were filled.

Seventeen cavities were filled with a calcium hydroxide base*[6] which occupied about one-half of the approximately 2 mm. deep cavities. The covering cement filled the remainder of the cavity and was also about 1 mm. in depth. Sixteen cavities were filled with zinc oxide–eugenol paste,†[7] and the filling was completed with oxyphosphate of zinc cement. Again, the cavity depths were about 2 mm. so that the zinc

*Serocalcium paste, Dr. Wild and Company, Basel, Switzerland. It is a white, slightly radiopaque paste of pH 12.2 composed of calcium hydroxide with salts of the human blood serum, sodium bicarbonate, calcium chloride, and potassium chloride.

†Cargenol, King's Specialty Company. It is available in powder and liquid form at pH 8.9: powder—zinc oxide and magnesium oxide; liquid—eugenol, thymol, and phenol.

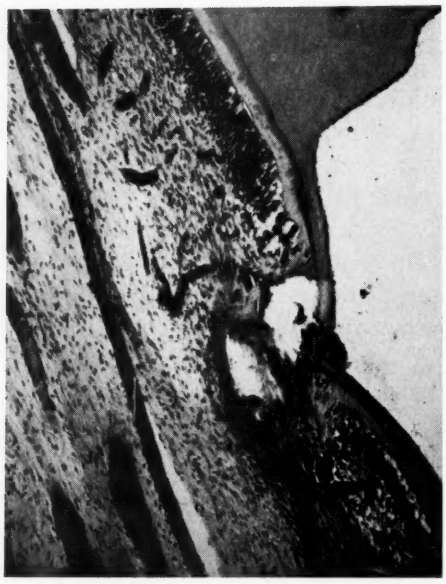

Fig. 2.—Magnification of the exposure and empty spaces into which calcium hydroxide paste had been forced. Note that there is little or no blood extravasation, hyperemia, or hemorrhage associated with this mild pulp injury. The dentinoid repair is extensive without odontoblasts. (×125; reduced ⅜.)

oxide-eugenol paste occupied the pulpal half and the cement the outer half of the cavity. Eleven cavities were completely filled with a mix of oxyphosphate of zinc cement.*

The animals were sacrificed 1 week after the cavities were filled. The teeth were cut off just apically to the cervix and placed with the pulp chambers wide open in 10 per cent buffered formaldehyde. After fixation, the teeth were decalcified, embedded in paraffin, sectioned serially 10 μ thick, and stained with hematoxylin and eosin. Some sections were cut longitudinally, some transversely.

RESULTS

Calcium Hydroxide Paste.—The first section of Table I shows that seventeen cavities were filled with calcium hydroxide. The first six cavities were deep cavities with intact cavity floors. The second group of eight showed clinical evidence of pulp exposure, whereas the third group of three were exposures undetected clinically but discovered in examining the histologic sections.

Where there was no pulp exposure, there was little or no evidence of pulp injury in spite of the fact that one cavity floor was only 0.025 mm. thick. In the second group, in which the pulp exposures were visible to the unaided eye of the dentist,

*Stratford-Cookson zinc cement, Stratford-Cookson Co. It is available in powder and liquid form: powder—zinc oxide and magnesium oxide; liquid—aluminum phosphate, phosphoric acid, and water.

Fig. 3.—An adjacent serial section. The thin layer of dentin and detinoid of the cavity floor was fractured during the processing of the slide. The dentinoid material shows evidence of active repair. The odontoblastic layer on both sides of the fracture is definitely disrupted. There is only a slight vascular change and no inflammation. (×125; reduced ⅜.)

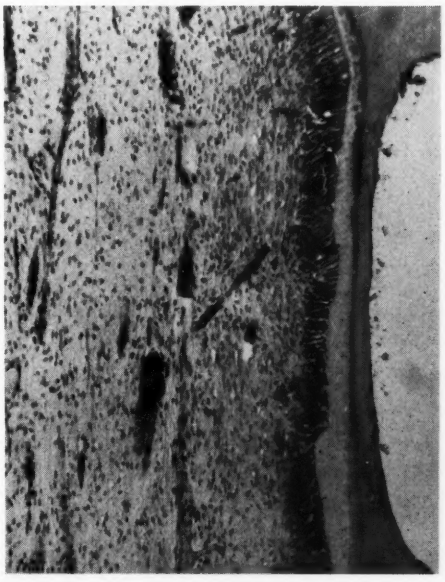

Fig. 4.—Another serial section. It shows the normal appearance of the pulp, a heavy calcio-traumatic line, and slightly thickened uncalcified secondary dentin matrix. The odontoblastic layer in the vicinity of the cavity floor is very slightly affected, and the rest of the pulp tissue appears normal. (×125; reduced ⅜.)

there seemed to be more evidence of pulp injury histologically than in those exposures which were seen only under the microscope. Two of the eight exposures with marked pulp injury showed evidence of repair. Two of the three exposures not seen clinically demonstrated definite attempts at repair during the 1 week interval after cavity preparation.

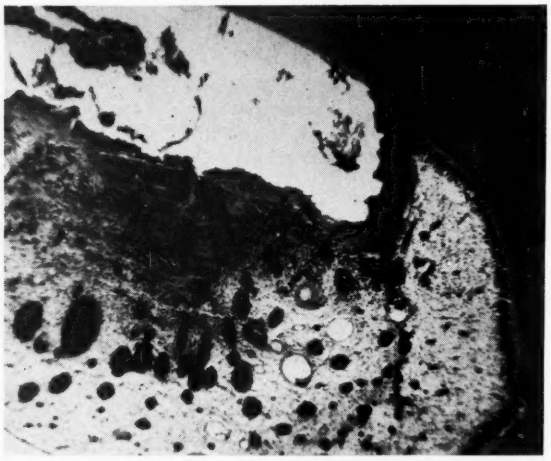

Fig. 5.—Magnification of a section from another pulp exposure through which calcium hydroxide paste had been forced into the pulp. The dentinoid bridge formation covers the surface of the injured pulp. There is no extravasation of blood in spite of the deep traumatic pulp injury. Blood vessels appear dilated, but there is no leukocytic infiltration or other sign of acute inflammation. (×125; reduced ⅜.)

The findings in Fig. 2 are interesting. There was in the cavity floor an extremely small area of pulp exposure which was not visible to the eye at the time the cavity was prepared. The illustration shows a plug of amorphous material in the microscopic exposure opening and a large space indicating that the calcium hydroxide paste had been forced through this microscopic opening into the peripheral pulp. There is a definite protective dentinoid membrane surrounding the space formerly occupied by the paste. The pulp around the area is compressed to appear as a pseudomembrane. Just apical to the space occupied by the paste, the odontoblastic layer appears to have been destroyed and replaced by red blood cells. There is no inflammation. This is an example of the fact that although there are blood vessels in the odontoblastic area, they are so small and so infrequent that no extensive visible hemorrhage occurs. It is obvious that microscopic pulp exposures are readily protected by a nonirritating material such as calcium hydroxide,[6] even though the material mechanically traumatizes the pulp.

Fig. 3, a photomicrograph of another serial section, does not show the space and compressed pulp. The fracture of the cavity floor seen in this illustration occurred during the processing of the slide. The odontoblasts have been destroyed, and there is some, but remarkably little, extravasation of red cells replacing them. This shows that unless serial sections are available, one might conceivably believe that

calcium hydroxide causes pulp injury through a thin layer of cavity floor dentin. There is no inflammation visible in the histologic section, again showing the protective effects of calcium hydroxide applied immediately after pulp exposure. Fig. 4 shows a photomicrograph of another serial section at a greater distance from the exposure than in Fig. 3. Little or no pulp injury is evident.

Fig. 5 shows marked pulp displacement by intruding paste. There is no evidence of inflammation, and the impression is that a good dentinoid protecting membrane is being fairly rapidly formed. This exposure is large enough that it is visible clinically. This is additional evidence that the immediate application of calcium hydroxide is an excellent protective agent for pulp exposure.

Zinc Oxide–Eugenol Paste.—An examination of the second section of Table I shows that in ten instances, although the cavities were deep, the zinc oxide–eugenol with phenol did not result in pulp injury unless there was an exposure of the pulp. There were six pulp exposures in this group. Five of the exposures were visible clinically, and one was not detected until the tissue was processed and examined under the microscope. Only one of these exposures showed evidence of healing without inflammation (Fig. 6). Apparently, when there is a pulp exposure, this paste can be, but is not necessarily, very irritating to the pulp. It was not possible,

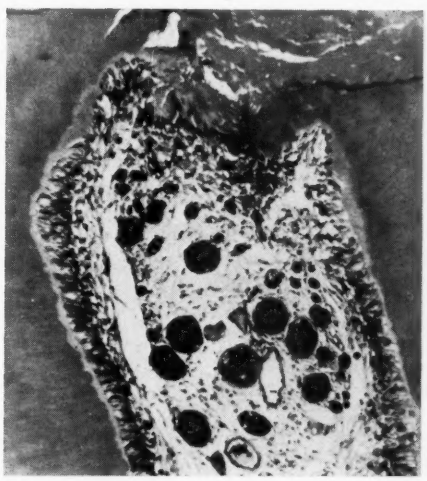

Fig. 6.—Magnification of the bridge of dentinoid tissue over the surface of the injured pulp. There is excellent repair in the presence of the irritating zinc oxide–eugenol capping material. Blood vessels in the pulp adjacent to the bridge are fairly numerous but much smaller than those of the body of the pulp. Odontoblasts adjacent to the injury have disappeared. There are few young fibroblasts in the dentinoid pulp margin. (×125; reduced ⅓.)

in this study, to determine why pulps exposed to zinc exide–eugenol survived in some instances and succumbed in others. One can only guess that the difference depended on how much contact there was between the irritating paste[7] and the exposed pulp in these teeth. There is also the possibility that the amount of operative trauma preceding the application may determine the pulp response.

Oxyphosphate of Zinc Cement.—The third section of Table I shows that when there was no pulp exposure, this material did not affect the pulp. On the other hand, in all instances in which a cement base was used over a pulp exposure, whether it was massive (visible clinically) or minimal (microscopic), there was clear evidence of focal necrosis.

DISCUSSION

Base Materials and the Unexposed Pulp.—In all deep cavities prepared with conventional or air-driven handpieces at ultra high speeds, where the cavity floors remained intact only minor pulp changes appeared. These consisted of calciotraumatic lines, thinning of the odontoblastic layer, and secondary dentin. There was no evidence of pulp injury, such as inflammation, after 1 week of contact between these cavity floors and calcium hydroxide paste, zinc oxide–eugenol paste, or oxyphosphate of zinc cement.

One purpose of this study was to determine whether or not base materials would penetrate a thin layer of cavity floor dentin to bring about pulp injury. It is impossible to determine how close the cavity floor is to the pulp at the time the cavity is cut. The cavities were deepened to, and sometimes beyond, the point where the red shadow of the pulp became visible. It can be noted in Table I that this method resulted in sixteen pulp exposures visible to the naked eye, eight microscopic exposures, many cavity floors that were 100 to 200 μ thick, and only one cavity floor that was 25 μ thick. What is needed to test the permeability of dentin cavity floors to the type base used is a number of cavity preparations with a floor 25 μ or less thick. Apparently, this is practically impossible to do with the present methods of cavity preparation.

The evaluation of cavity floor pulp proximity in these teeth from dogs was very difficult in spite of the facts that there was no caries stain and the field of operation was clearly visible to the eye with some magnification. Such evaluation would be still more difficult in operating on carious lesions in the human oral cavity. Therefore, because it is practically impossible to evaluate cavity floor pulp proximity in the oral cavity, every deep cavity should be considered an exposure and covered with proved nonirritating calcium hydroxide.

Further research should be done on the readily accessible canine teeth of dogs. Some type of magnifying device should be used in this type of research to determine more accurately, if possible, the thickness of the cavity floor at the time of cavity preparation.

Base Materials and the Exposed Pulp.—Microscopic pulp exposure may occur in preparing a deep cavity and may not be detected clinically at the time (Table I). Examination of the histologic slides shows that pulp exposures visible microscopically, but not clinically, reveal less mechanical pulp destruction as a rule. There is little or no extravasation of red blood cells. In fact, examination of the distribution of the blood vessels in the healthy normal pulp in Fig. 7 shows that there are very few blood vessels of any size visible in the marginal zone of an injected pulp. In the layer of Weil, these thin wall blood vessels are still capillary in size, although the vessels are more numerous than they are in the odontoblastic layer. It is only in

the pulp proper, or just inside of the zone of Weil, that one sees numerous large, thin wall blood vessels. It has been shown by both Meyer[8] and James[9] that marginal pulp blood vessels are capillary in size, whereas larger, thin wall blood vessels occur in the central part of this tissue. James[9] showed that the capillaries are always in close relation to the odontoblasts, although rarely among them. It is possible that the reason why shallow, marginal pulp exposures do not bleed, and thus are not visible clinically, is that when cut these capillaries seal themselves or are sealed by the force of the cutting instrument. It is only when the layer of Weil or deeper portions of the pulp become lacerated that large enough blood vessels are involved to produce visible hemorrhage.

In the treatment of deep cavities, particularly in the teeth of young patients, the dentist must fully appreciate the microscopic details of pulp margins. There is no way to detect minute pulp exposures except by visible evidence of hemorrhage, and microscopic pulp exposure may occur in preparing a deep cavity without being detected clinically. Until dentistry has developed a more precise, that is, microscopic, method for detecting pulp exposures clinically, every deep cavity preparation must be considered a pulp exposure and treated as such.

Fig. 7.—Magnification of a histologic section of a normal healthy pulp margin with the vessels injected shows clearly that the capillary loops in the odontoblastic layer are not frequent. One must penetrate the layer of Weil before encountering blood vessels of any size. (×125; reduced 1/5.) (From Churchill, H. R.: Meyer's Normal Histology and Histogenesis of the Human Teeth and Associated Parts, Philadelphia, 1935, J. B. Lippincott Company.)

In spite of the fact that minute exposures are not large enough to produce visible bleeding, they do not have to be large to admit bacteria and the irritating fluids of the semisolid plastic fillings that are packed against the cavity floor and walls under pressure. No one knows how much pressure is exerted when plastic filling materials are placed by instruments and strips. It is obvious from Fig. 2, however, that these pressures need not be great. It is also obvious that packing pressures of some plastic filling materials are of considerable magnitude and quite capable of forcing soft materials into the pulp tissues. It is also possible that medica-

ments used for drying the cavities or for sterilizing the walls of the cavities might also gain access to a pulp through invisible though microscopic patent exposures.

Kozam and Burnett[10] have developed a direct microscopic method for studying the effect on the pulp of chemicals used in dental procedures. They showed that epinephrine would affect a pulp through a thin layer of dentin but orthophosphoric acid would not until the thin layer had become decalcified.

CONCLUSIONS

1. Where there was any thickness of dentin between the calcium hydroxide paste, zinc oxide–eugenol paste, or oxyphosphate of zinc cement bases and the pulp, there was no evidence of pulp injury. This was true whether conventional or ultra high speed instruments were used.

2. Clinically undetected, microscopic pulp exposures occurred in deep cavities, and if serial histologic sections had not been used, the actual exposures would have been undetected.

3. In pulp exposures, calcium hydroxide paste was found to be the least irritating of the pulp-capping materials tested. Zinc oxide–eugenol paste was destructive in four cases but was not in one. It is believed that a potential irritant should not be used for pulp capping. Oxyphosphate of zinc cement caused severe pulp necrosis and is, therefore, contraindicated for use in deep cavities without a protective non-irritating base.

4. Clinically undetected pulp exposures admit plastic restorative materials to the pulp. Bacteria could also gain access through microscopic exposures.

5. The blood vessels of the odontoblastic layer are capillary in size and widely scattered so that relatively little, if any, hemorrhage or extravasation of blood occurs after microscopic exposure.

RECOMMENDATIONS

1. Because pulp exposures may be invisible to the eye of the dentist and irritating bacteria and restorative materials may injure the pulp through such undetected openings, all deep cavities should be lined with a calcium hydroxide base before any restoration is placed.

2. Some precise clinical microscopic method should be developed for evaluating the condition of deep cavity floors before insertion of bases for restoration.

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EFFECT OF RETRACTION MATERIALS ON THE GINGIVAL SULCUS EPITHELIUM

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DENTISTS GENERALLY BELIEVE that retraction materials used in making elastic impressions cause no injury to the gingival sulcus epithelium. Also, they concur that if injury does occur, healing is complete within 24 hours.[1] Reports in the literature state that, clinically, no injury to the sulcal epithelium results from retraction; however, certain caustics may cause a slough with prolonged use.[2-6]

The following questions were considered in this study: (1) Do chemical and mechanical retraction materials injure the gingival sulcus epithelium? (2) If so, is the injury permanent or temporary? (3) If injury occurs, which retraction materials do cause injury? (4) Which retraction materials do not cause injury?

Since injury to the sulcal epithelium cannot be detected clinically except after the most severe damage, this study was based on histologic findings. A review of the literature did not reveal any previous investigation of a similar nature.

EXPERIMENTAL PROCEDURES AND RESULTS

Three dogs were used as the experimental animals. The gingival sulcus epithelium and the crevice depth in dogs are similar in stucture to those of humans.

Dogs 3 to 5 years old were selected to approximate the general age of persons in whom retraction materials are most frequently used.

The retraction materials were untreated string and string saturated with (1) 1:1,000 epinephrine, (2) 8 per cent epinephrine, (3) 100 per cent alum, (4) 8 per cent zinc chloride, or (5) 40 per cent zinc chloride.

Each animal was anesthetized with thiopental (veterinary) by intravenous injection. The labial or buccal sulcus was retracted with each material for periods of 5, 10, and 30 minutes.† For example, the buccal gingiva of the mandibular right first bicuspid was retracted with the string for 5 minutes, then the string was removed. The lingual sulcus was used as a control in each instance. The tissue on the control side was manipulated with instruments, but retraction materials were not used. So all conditions were the same except for the use of retraction materials.

Block specimens including the teeth and soft tissues were taken immediately and at 7 days, 10 days, 14 days, and 21 days. The specimens were fixed, decalcified,

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This study was completed at the Ohio State University, Columbus, Ohio, in partial fulfillment of the requirements for the degree of Master of Science and was supported by a postdoctoral fellowship from the U. S. Public Health Service.

*Assistant Professor and Director, Department of Crown and Bridge Prosthodontics.

†The experiments were conducted according to the "Rules Regarding Animal Care" as established by the American Medical Association.

TABLE I. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH UNTREATED STRING

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Normal	Normal	Normal	Normal	Normal
10	Normal	Normal	Normal	Normal	Normal
30	Slight	Slight	Normal	Normal	Normal

TABLE II. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH STRING SATURATED WITH 1:1,000 EPINEPHRINE

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Normal	Normal	Normal	Normal	Normal
10	Normal	Slight	Normal	Normal	Normal
30	Slight	Slight	Normal	Normal	Normal

TABLE III. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH STRING SATURATED WITH 8 PER CENT EPINEPHRINE

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Slight	Slight	Normal	Normal	Normal
10	Slight	Slight	Normal	Normal	Normal
30	Moderate	Slight	Slight	Normal	Normal

TABLE IV. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH STRING SATURATED WITH 100 PER CENT ALUM

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Slight	Normal	Normal	Normal	Normal
10	Slight	Normal	Normal	Normal	Normal
30	Moderate	Moderate	Slight	Normal	Normal

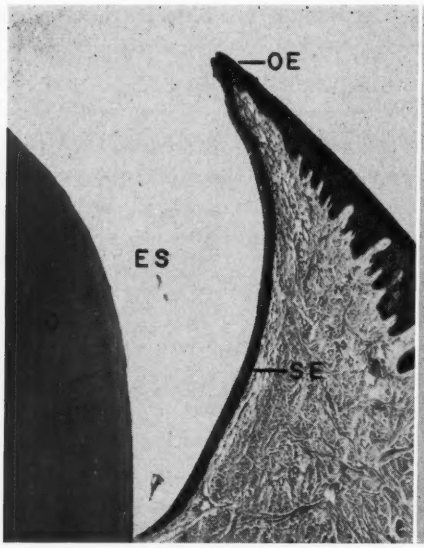

Fig. 1.

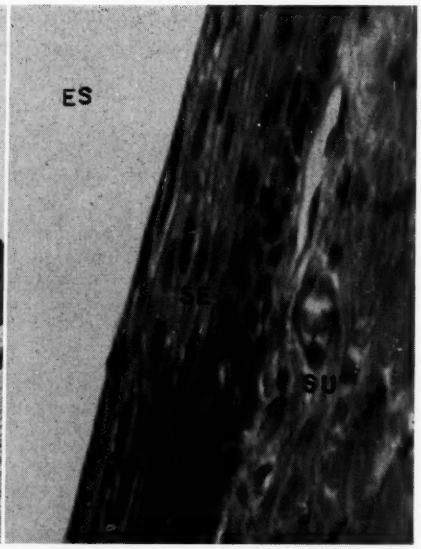

Fig. 2.

Fig. 1.—*Normal* gingival sulcus epithelium: *(D)* dentin; *(ES)* enamel space; *(SE)* sulcal epithelium; *(OE)* oral epithelium (×35; reduced ⅜).

Fig. 2.—*Normal* gingival sulcus epithelium: *(SU)* submucosa (×450; reduced ⅜).

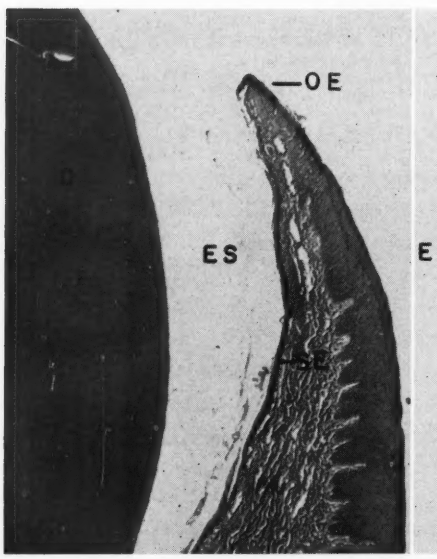

Fig. 3.

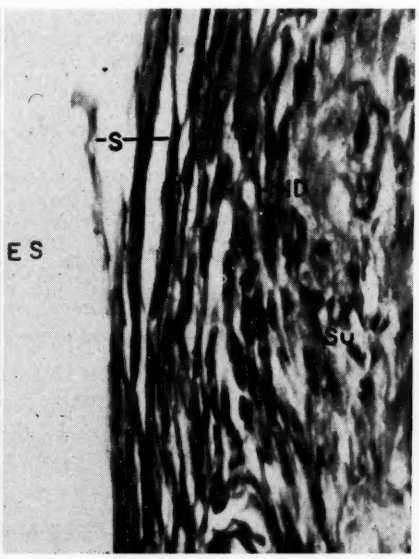

Fig. 4.

Fig. 3.—*Slight* injury to the gingival sulcus epithelium: *(D)* dentin; *(ES)* enamel space; *(SE)* sulcal epithelium; *(OE)* oral epithelium (×35; reduced ⅜).

Fig. 4.—*Slight* injury to the gingival sulcal epithelium: *(S)* stripping; *(IHD)* intracellular hydropic degeneration; *(Su)* submucosa (×450; reduced ⅜).

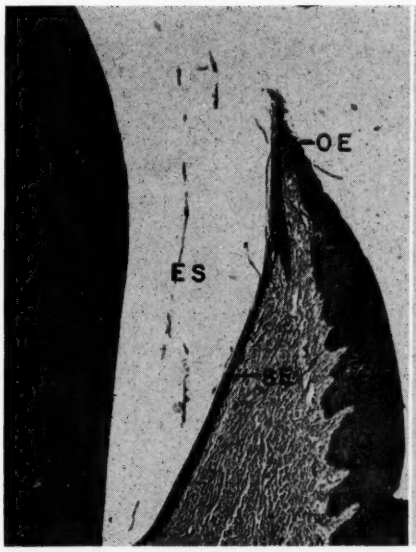

Fig. 5.

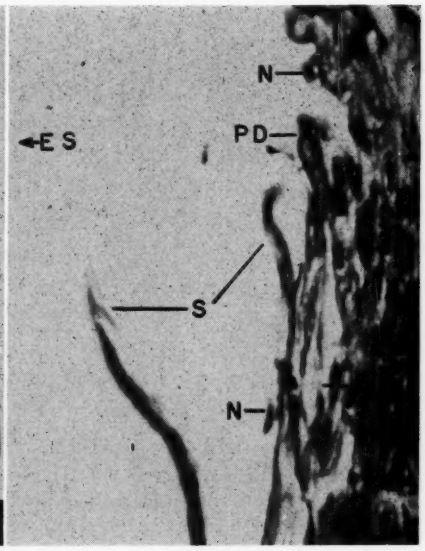

Fig. 6.

Fig. 5.—*Moderate* injury to the gingival sulcus epithelium: *(D)* dentin; *(ES)* enamel space; *(SE)* sulcal epithelium; *(OE)* oral epithelium (×35; reduced ⅜).

Fig. 6.—*Moderate* injury to the gingival sulcus epithelium: *(S)* stripping; *(PD)* pathologic desquamation; *(IHD)* intracellular hydropic degeneration; *(N)* slight necrosis (×450; reduced ⅜).

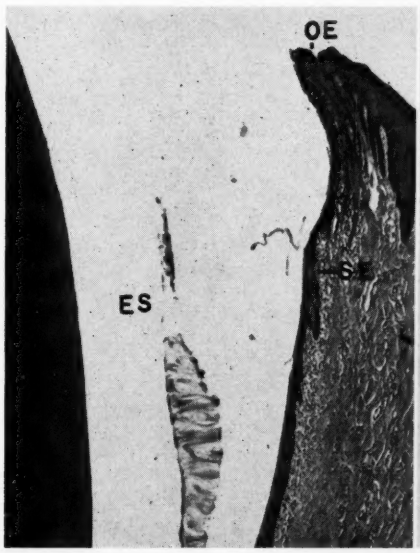

Fig. 7.

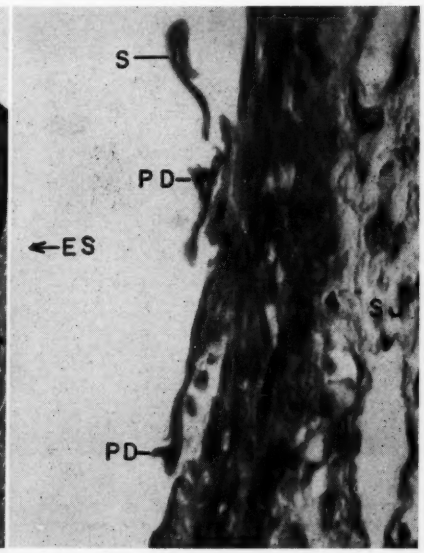

Fig. 8.

Fig. 7.—*Slight* injury to the gingival sulcus epithelium from 8 per cent epinephrine and 100 per cent alum in the 10 day, 30 minute specimens: *(D)* dentin; *(ES)* enamel space; *(SE)* sulcal epithelium; *(OE)* oral epithelium (×35; reduced ⅜).

Fig. 8.—*Slight* injury to the gingival sulcus epithelium from 8 per cent epinephrine and 100 per cent alum in the 10 day, 30 minute specimens: *(S)* stripping; *(PD)* pathologic desquamation; *(Su)* submucosa (×450; reduced ⅜).

Fig. 9. Fig. 10.

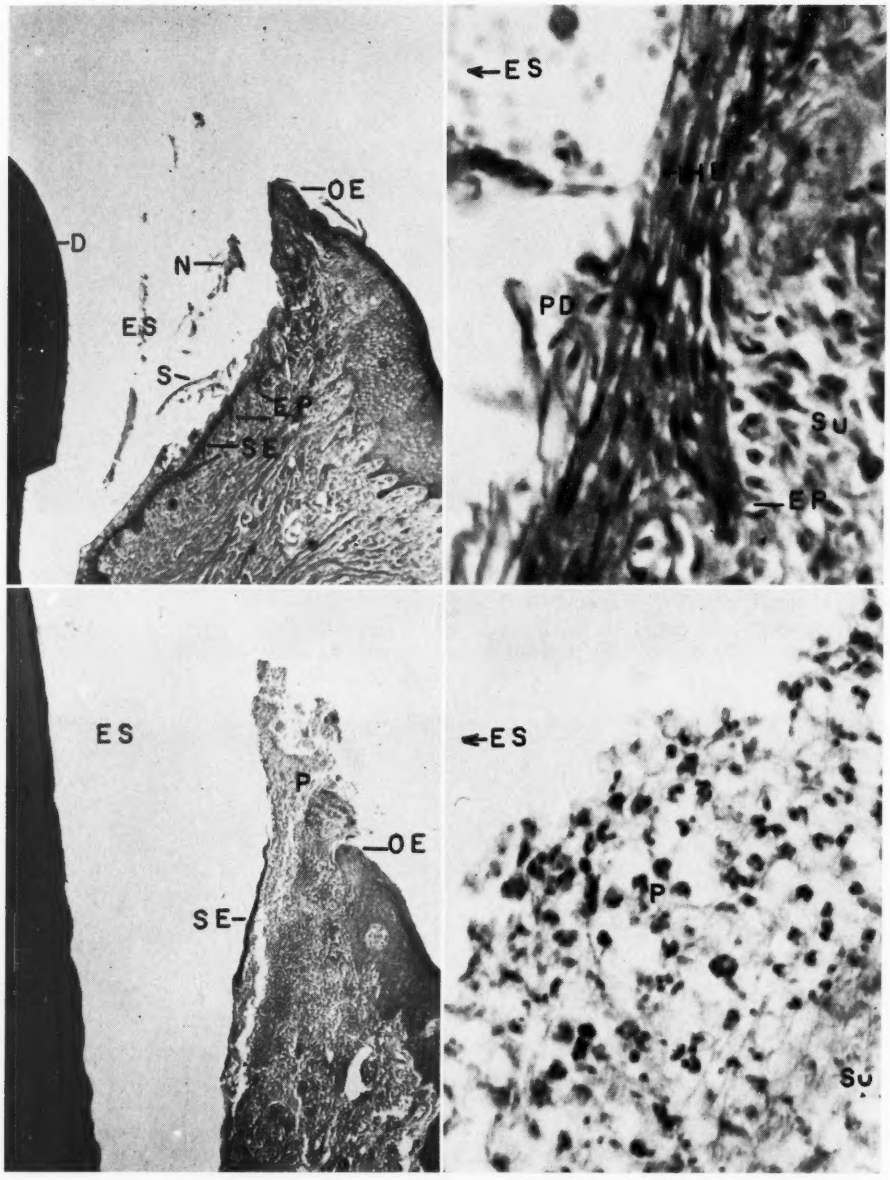

Fig. 11. Fig. 12.

Fig. 9.—*Severe* injury to the gingival sulcus epithelium: *(D)* dentin; *(ES)* enamel space; *(SE)* sulcal epithelium; *(OE)* oral epithelium; *(S)* stripping; *(EP)* epithelial proliferation; *(N)* necrosis (×35; reduced ⅓).

Fig. 10.—*Severe* injury to the gingival sulcus epithelium: *(IHD)* intracellular hydropic degeneration; *(PD)* pathologic desquamation; *(Su)* submucosa (×450; reduced ⅓).

Fig. 11.—*Severe* injury to the gingival sulcus epithelium from 40 per cent zinc chloride in the 7 day, 30 minute specimen: *(SE)* remains of sulcal epithelium; *(P)* pus formation with many polymorphonuclear leukocytes (×35; reduced ⅓).

Fig. 12.—*Severe* injury to the gingival sulcus epithelium from 40 per cent zinc chloride in the 7 day, 30 minute specimen: *(Su)* remains of submucosa (×450; reduced ⅓).

and processed for histologic study. All specimens were stained with hematoxylin and eosin.

Clinical Examination.—No gingival inflammation was observed before or after each procedure. The general oral condition was good in each dog.

Histologic Examination.—Since cellular response to the retraction materials was the main interest, the following criteria were used to determine the changes: stripping, desquamation of epithelium, intracellular hydropic degeneration, hyperemia, inflammatory cells, epithelial proliferation, and necrosis.[7,8]

For the purpose of comparison, a section of normal gingival sulcus epithelium is shown in Figs. 1 and 2.

Microscopic sections of the experimental and control areas on the same tooth were obtained by cutting labiolingual and buccolingual block sections.

The results are presented in table form. The relative degree of injury caused by each retraction material is indicated by normal and by slight, moderate, or severe, using the criteria mentioned above. The control side (lingual) was normal in all but a few instances.

DISCUSSION

Results of animal experimentation with dogs may be interpreted as valid in meaning for man. However, the tissue reaction is generally less severe in dogs than in man; therefore, it may be assumed that the type of injury or irritation produced in a dog would be more severe in man.[7]

The experimental results indicated that mechanical and chemical retraction materials *do* cause injury to the gingival sulcus epithelium. The injury varied from slight to severe.

Untreated string and string saturated with 1:1,000 epinephrine did not injure the sulcal epithelium (Figs. 1 and 2) in the 5 and 10 minute retraction periods (Tables I and II). After 30 minutes, however, both materials caused slight injury to the sulcal epithelium in the area of application (Figs. 3 and 4). These areas healed within 10 days.

Effects of Epinephrine and Alum.—String saturated with 8 per cent epinephrine and with 100 per cent alum caused injury to the sulcal epithelium; the injuries were similar in nature (Figs. 5 and 6). These injuries increased in severity as the retraction time increased. After 7 days, healing was not complete in the specimens retracted with string saturated with 8 per cent epinephrine (Table III). The specimens retracted for the 5 and 10 minute periods with string saturated with alum solution had healed (Table IV).

At the end of 10 days, histologic examination of the sulcal epithelium revealed it to be normal for the 5 and 10 minute retraction periods. However, in the 30 minute specimens, there was slight injury in the area of application (Figs. 7 and 8). Even these specimens taken at 30 minutes healed in 14 days.

Effects of Zinc Chloride.—Zinc chloride strings (8 and 40 per cent saturation) caused severe injury to the sulcal epithelium (Tables V and VI). The injury from the 40 per cent–saturated string was more severe, and the severity increased as the retraction time increased. Both of the 7 day specimens showed similar injury, and

TABLE V. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH STRING SATURATED WITH 8 PER CENT ZINC CHLORIDE

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Severe	Severe	Moderate	Moderate	Moderate
10	Severe	Severe	Moderate	Moderate	Moderate
30	Severe	Severe	Severe	Severe	Severe

TABLE VI. RELATIVE DEGREE OF INJURY CAUSED BY RETRACTION WITH STRING SATURATED WITH 40 PER CENT ZINC CHLORIDE

RETRACTION TIME (MIN.)	INTERVAL BEFORE TAKING SPECIMEN				
	IMMEDIATE	7 DAYS	10 DAYS	14 DAYS	21 DAYS
5	Severe	Severe	Severe	Severe	Severe
10	Severe	Severe	Severe	Severe	Severe
30	Severe	Severe	Severe	Severe	Severe

there was no evidence of healing (Figs. 9 and 10). Pus formation with many polymorphonuclear leukocytes was seen in the 30 minute specimens (Figs. 11 and 12). In the 10 day sections, string saturated with 8 per cent zinc chloride still showed a moderate amount of injury (Figs. 5 and 6). The 14 and 21 day specimens saturated with 8 per cent zinc chloride showed injury varying from moderate to severe (Table V). The 10, 14, and 21 day specimens of string saturated with 40 per cent zinc chloride all showed severe gingival sulcus epithelium injury (Table VI).

CONCLUSIONS

On the basis of these findings, the following points concerning the use of retraction materials in patients may be concluded:

1. Mechanical and chemical retraction materials used with elastic impression materials do injure the gingival sulcus epithelium. The injuries, *excluding* those caused by the zinc chloride concentrations, healed within 7 or 10 day periods and may be considered temporary.

2. Untreated string is a safe retraction material for periods from 5 to 30 minutes and is recommended when bleeding or seepage is not a problem. String saturated with 1:1,000 epinephrine is a safe retraction material for periods from 5 to 30 minutes and is recommended when bleeding or seepage is a problem.

3. String saturated with 8 per cent epinephrine or 100 per cent alum solution may be used when heavier bleeding or seepage must be controlled. They are recommended for 5 and 10 minute retraction periods.

4. String saturated with 8 or 40 per cent zinc chloride is not recommended as a retraction material.

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EFFECT OF SILICATE, AMALGAM, AND CAST GOLD ON THE GINGIVA

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DOES IT HARM OR BENEFIT the patient to extend restorations into the gingival sulcus?

"Extension for prevention" has been standard practice for many years. Four of the six classes of restorations, crowns, orthodontic bands, and other dental materials are carried below the gingival margins. Waerhaug and Zander[1] have questioned the desirability of extending restorations into the gingival sulcus. Zander[2] found that "a comparison of the gingival irritation from silicate cement, amalgam, and acrylic restorations shows that all of these materials produce a chronic inflammation."

This study substantiates the conclusions of Waerhaug and Zander and presents the additional finding that cast gold restorations do not cause inflammation when extended into the gingival sulcus.

MATERIALS AND METHODS

Thirty-six class V preparations that extended beneath the crest of the gingival tissues were prepared in the gingival third of the buccal surfaces of a young dog's teeth.† The preparations were made with a No. 558 carbide bur in an air-driven handpiece. Twelve cavities were filled with silicate cement, twelve with amalgam, and twelve with cast gold inlays.

The silicate fillings were retained in the cavity by a plastic matrix. Twenty-four hours later they were polished with lubricated fine garnet strips.

Amalgam fillings were contoured immediately after insertion. The gingival sulcus was flushed free of amalgam debris. Twenty-four hours later, the amalgam restorations were polished with Burlew disks and with tin oxide and a rubber cup.

Cast gold inlays were finished with a Burlew disk before cementation. The margins were dressed with gold files while the cement was setting. Twenty-four hours after insertion, the inlays were polished with tin oxide and a rubber cup.

Controls.—The lingual surface of the same tooth served as the control for each restoration. The only exceptions were the cavity preparation and the insertion of a restoration. To simulate the effect of cavity preparation on the control side,

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†The experiments were conducted according to the "Rules Regarding Animal Care," as established by the American Medical Association.

a No. 558 bur with the end blades removed was applied to the enamel in the sulcus area. This was done to each tooth for the same period of time required for the cavity preparation. The filling material was the remaining difference between the experimental side and the control side.

Specimens.—Block specimens including the restored teeth and soft tissues were taken at 7 days and 30 days. These specimens were fixed, decalcified, and processed for histologic examination. All sections were stained with hematoxylin and eosin.

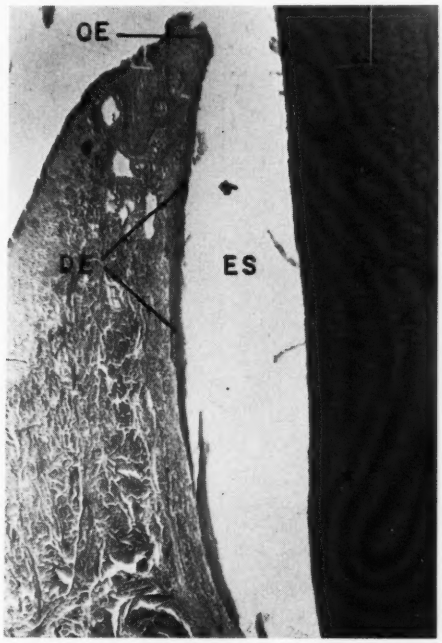


Fig. 1.—Section of the normal untouched gingival sulcus of a dog: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium. (Hematoxylin and eosin ×35; reduced ¼.)

RESULTS OF EXPERIMENTS

Clinical Examination.—Gingival tissues in the experimental and control areas were normal clinically. The margins of the restorations were tested with an explorer and were found to be satisfactory.

Histologic Examination.—Since cellular response to the restorative materials was the main interest, the following known criteria were used to determine the changes: intracellular hydropic degeneration, epithelial proliferation, and the presence of inflammatory cells.

Microscopic sections of the experimental and control areas on the same tooth were obtained by cutting buccolingual block specimens.

For purposes of comparison, a section of a normal gingival sulcus is shown in Fig. 1. The enamel has been lost in decalcification. The oral mucosa, identified by the granular layer and stratum corneum, extends into the sulcal epithelium.[3] The dental epithelium consists of several layers of stratified squamous epithelium and a layer of cuboidal basal cells. There are no inflammatory cells in the submucosa.

Fig. 2.

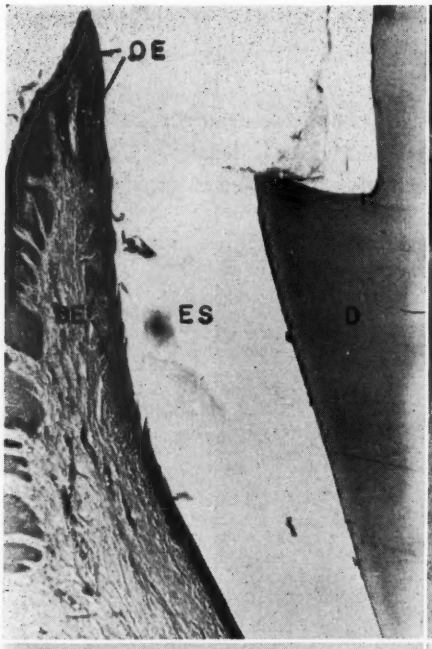
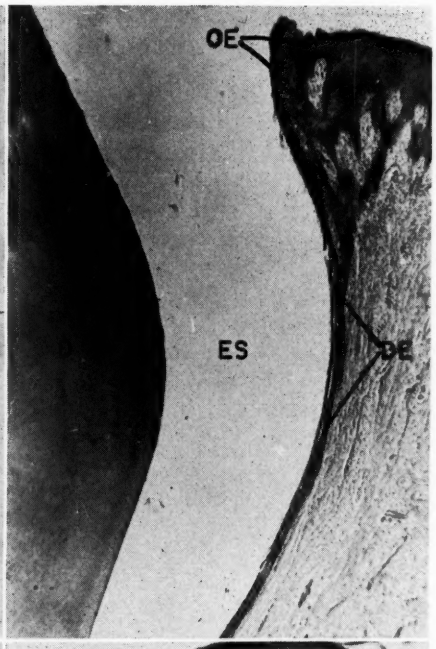


Fig. 3.



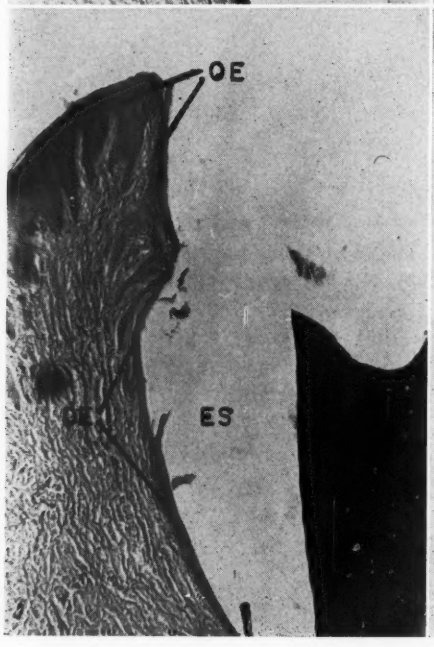


Fig. 4.

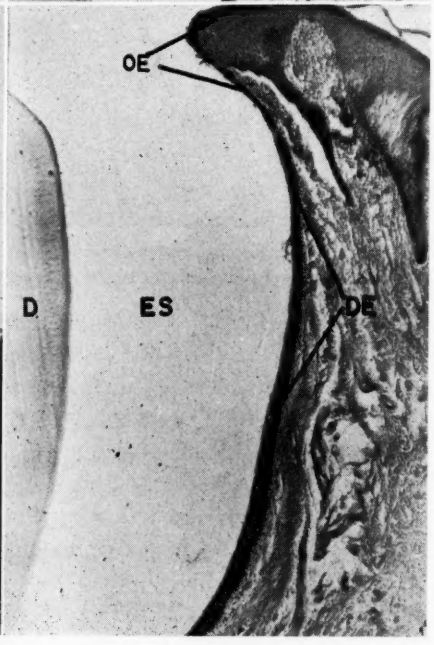


Fig. 5.

Fig. 2.—Section of the gingival sulcus of a dog; silicate restoration in place 7 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium. Note the budding proliferation of dental epithelium. (Hematoxylin and eosin ×35; reduced ¼.)

Fig. 3.—Section of the gingival sulcus of a dog; 7 day control for Fig. 2. This section illustrates injury from instrumentation only. Note the response to injury at the gingival crest.

Fig. 4.—Section of the gingival sulcus of a dog; silicate restoration in place 30 days.

Fig. 5.—Section of the gingival sulcus of a dog; 30 day control for Fig. 4. This section illustrates only the extent of instrumentation injury.

Silicate.—Seven days after the insertion of the silicate restoration, the dental epithelium, which was in contact with the restoration, showed a budding invagination into the underlying connective tissue (Fig. 2). There was a dense cellular infiltration in the area, with extensive hydropic degeneration of the surface epithelial cells. Some surface layers of epithelium were separated in longitudinal strips. Many more blood vessels were seen in the underlying connective tissue.

The opposing control side of the tooth showed the effects of instrumentation alone (Fig. 3). The dental and oral epithelium was undisturbed except at the crest. There the inflammation and epithelial invaginations were accepted as a result of instrumentation. There was minimal hydropic degeneration. No increase in vascularity was noted.

Thirty days after insertion of the silicate restorations, budlike invaginations of the dental epithelium and inflammation persisted on the experimental side (Fig. 4). There was hydropic degeneration of the surface dental epithelial cells, which was also seen at 7 days (Fig. 3). In contrast to the control (Fig. 5), there was an unusual surface epithelial projection in the area of the gingival margin of the filling. It seemed to be related to the restoration.

The control side (Fig. 5) demonstrated no abnormalities. There was a notable lack of inflammation in the epithelium of the gingival sulcus. Cells demonstrating hydropic degeneration were absent.

Amalgam.—Seven days after the insertion of the amalgam restorations, budding proliferation of the epithelium was evident in the subjacent connective tissue (Fig. 6). A dense cellular infiltration extended from the oral epithelium to half the length of the dental epithelium. Hydropic degeneration, though present in the surface dental epithelium, was less than that found in the silicate restorations (Figs. 2 and 4).

Only manifestations of injury from instruments were seen in the control side (Fig. 7). Once again, as in the case of the silicate control (Fig. 3), there was an inflammatory infiltration into the submucosa. Several epithelial strands extended into the underlying connective tissue. A few surface dental epithelial cells demonstrated hydropic degeneration. Several areas showed transverse separations of the superficial layers.

The 30 day amalgam specimen showed a deeper penetration of the epithelial buds into the connective tissue (Fig. 8). Then the proliferation extended one-third the length of the dental epithelium. Cellular infiltration and increased vascularity dominated the picture. Many round cells were present in the underlying connective tissue. Hydropic degeneration was prominent in the surface dental epithelial cells. In the space once occupied by the enamel, there was a strip of cells adjacent to a frayed portion of the dental epithelium.

The control side, affected only by instrumentation, showed no epithelial proliferation (Fig. 9). A few inflammatory cells were present at the crest of the gingival margin. Unusual vascularity and hydropic degeneration were absent.

Gold.—Seven days after the insertion of a cast gold inlay, there was considerable epithelial budding at the junction of the oral and dental epithelium (Fig. 10). Cellular infiltration was obvious, as well as an increase in vascularity of the subjacent connective tissue. Few cells showed hydropic degeneration, although the surface dental epithelial cells were separated midway in the sulcus.

The control side presented the same picture as the experimental side (Fig. 11). Epithelial budding and heavy cellular infiltration were prominent. Very little hydropic degeneration was present.

The 30 day cast gold specimen demonstrated a slight thinning of the dental epithelium at the area of contact with the restoration (Fig. 12). There was a marked absence of the epithelial proliferation and inflammatory cells in contrast to the silicate and amalgam specimens (Figs. 3 and 7). There was a "stripping" of the surface layer or two of the dental epithelial cells near the cervical margin of the restoration.

Examination of the opposing or control side showed a few epithelial buds but a lack of inflammatory cells (Fig. 13). Several dental epithelial cells demonstrated hydropic degeneration, with longitudinal separations occurring in the surface layers.

DISCUSSION

Moderate injury produces an inflammatory response in the gingival tissues. In the sulcus epithelium, the response to injury also includes superficial cell degeneration and invaginating epithelial proliferation from the germinal layer. The proliferation into the deeper layers of connective tissue is evident from the number of round, young epithelial cells at the fundus of the buds. These cells are unlike the

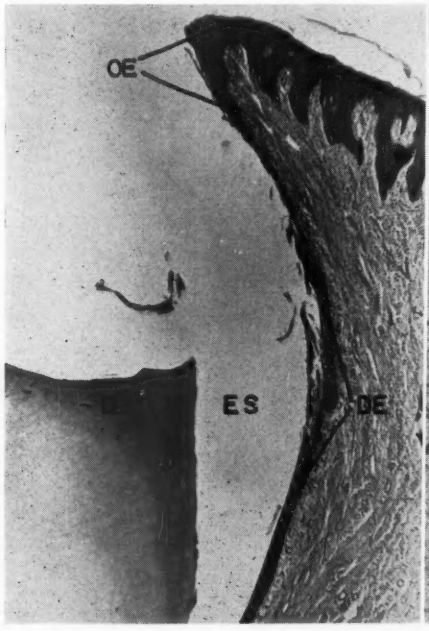


Fig. 6.

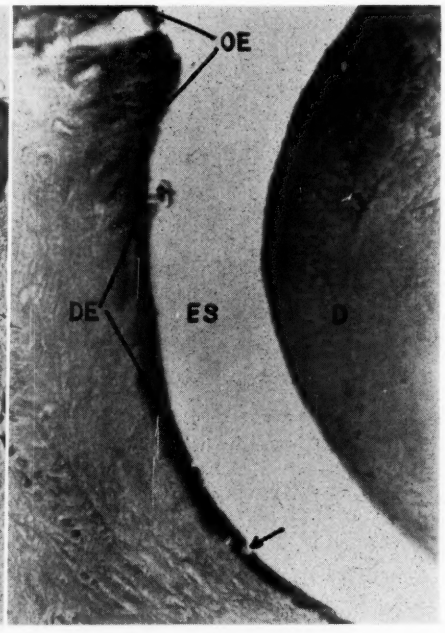


Fig. 7.

Fig. 6.—Section of the gingival sulcus of a dog; amalgam restoration in place 7 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium. (Hematoxylin and eosin ×35; reduced ¼.)

Fig. 7.—Section of the gingival sulcus of a dog; 7 day control for Fig. 6. This section illustrates injury from instrumentation only. The arrow points to a separation of the surface layer of dental epithelium.

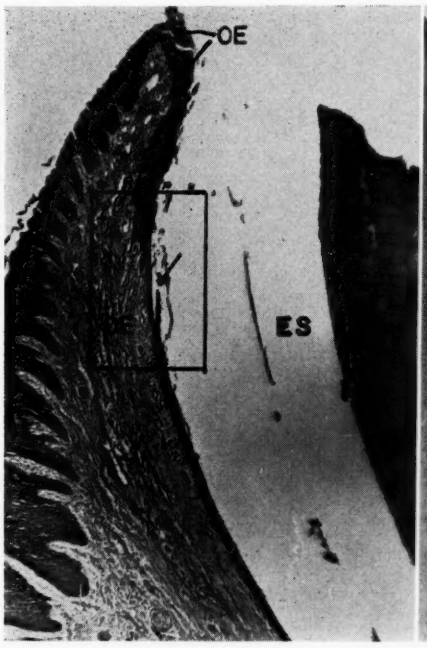


Fig. 8.

Fig. 9.

Fig. 8.—Section of the gingival sulcus of a dog; amalgam restoration in place 30 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium. Note the budding epithelial invagination into connective tissue. The arrow points to a tear in the surface dental epithelium. See Fig. 14 for higher magnification of the area enclosed by the rectangle. (Hematoxylin and eosin ×35; reduced ¼.)

Fig. 9.—Section of the gingival sulcus of a dog; 30 day control for Fig. 8. This section illustrates only injury from instrumentation. The arrow points to a separation of surface layers of dental epithelium.

flattened, older cells found adjacent to the enamel (Fig. 14). The presence of lymphocytes, plasma cells, and leukocytes is evidence of the injury to the gingival sulcus epithelium.[4]

In this study, the effects of clinically satisfactory silicate, amalgam, and cast gold restorations were examined to determine the extent of soft tissue injury produced by these materials. The results confirm Zander's[2] findings that silicate and amalgam restorations produce a chronic inflammation of the adjacent gingival tissues (Figs. 2, 4, 6, and 8). However, the sulcus epithelium showed no response to the cast gold restorations as noted by Zander[5] (Figs. 10 and 12).

The tissue response to silicate and amalgam (Figs. 8 and 14) and to orthodontic bands (Fig. 16) is the same as the tissue response to calculus (Fig. 15). Since calculus is an etiologic factor in periodontal disease and the sulcus epithelium responds to silicate and amalgam as it does to calculus, these restorative materials must also be considered etiologic factors in periodontal disease.

If silicate and amalgam produce chronic inflammation of the gingival tissues, why are they placed in the gingival sulcus? G. V. Black's[6] rule of "extension for prevention" is the answer. It has been known since 1772[7] that gingival recession

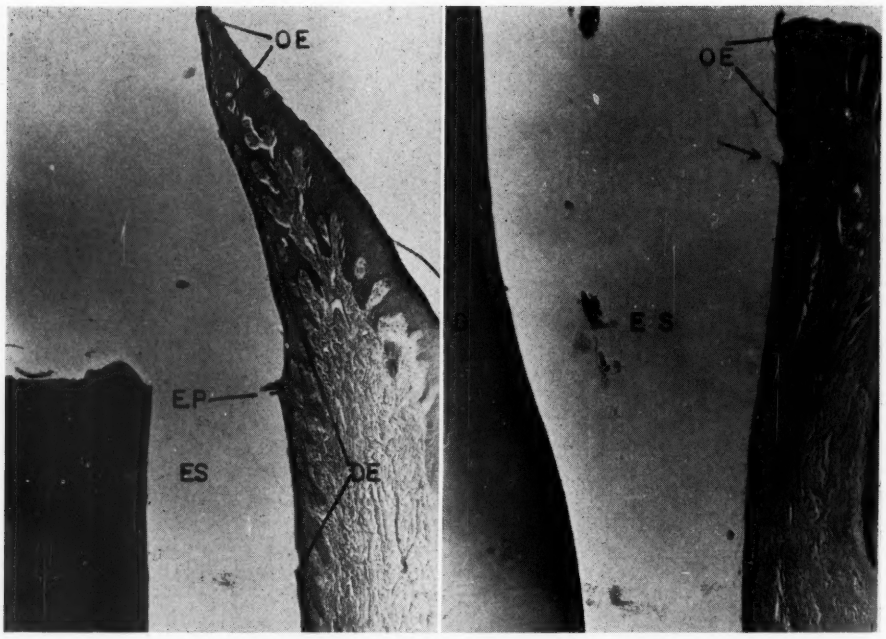


Fig. 10. Fig. 11.

Fig. 10.—Section of the gingival sulcus of a dog; cast gold inlay in place 7 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium. Note the epithelial projection *(EP)* at the area of the gingival margin of the restoration. (Hematoxylin and eosin ×35; reduced ¼.)

Fig. 11.—Section of the gingival sulcus of a dog; 7 day control for Fig. 10. Instrumentation injury alone is demonstrated in this section. The arrow points to a tear in surface layers of dental epithelium.

continues with age whether restorations are present or not. Zander[2] suggested that injury caused by restorative materials in the gingival sulcus may result in gingival recession of normal tissue. This recession is also evident clinically with jacket crowns. The restorations extended into the gingival sulcus today may not be in the sulcus in the future.

It is true that the degree of tissue response and gingival recession varies with each individual. But, how much can these soft tissues be injured before they break down? Constant irritation from silicate and amalgam restorations and continuous gingival recession leave but one conclusion: we must re-evaluate the extension of the cavity preparations for these two materials or anticipate the surgical reduction of the soft tissue. The results of surgical tissue reduction are the same as with extension of the gingival margins of these restorations only as far as the gingival crest. In either event, "the institution of a good oral hygiene regime will keep the gingival margins clean for the patients and prevent the recurrence of secondary caries."[18]

A comparison of the gingival irritation from silicate, amalgam, and cast gold restorations shows that silicate and amalgam produce a chronic inflammation while the soft tissues are more tolerant to the cast gold restorations.[5]

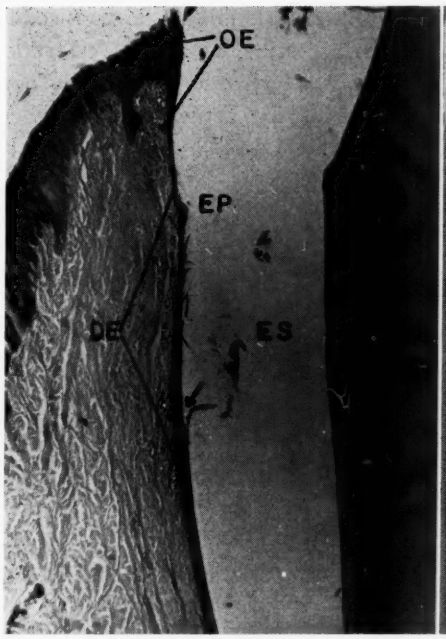


Fig. 12

Fig. 13.

Fig. 12.—Section of the gingival sulcus of a dog; cast gold inlay in place 30 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium; *(EP)* epithelial projection. The arrow points to a tear in surface layers of dental epithelium. (Hematoxylin and eosin ×35; reduced ¼.)

Fig. 13.—Section of the gingival sulcus of a dog; 30 day control for Fig. 12. Instrumentation injury alone is illustrated in this section. Note the recession of epithelial budding.

Except for the preparation of the cavity, a cast gold restoration shows no pathologic tissue response.

This study confirms another finding originally established by Zander and Waerhaug. The unusual epithelial projection in the area of the gingival margin of the restorations indicates that there was a minute crevice between the restoration and the tooth (Figs. 4, 10, and 12).[1,2] Here, epithelium is fulfilling its covering function as it grows into the crevice.[8] The end result is a crevice filled with necrotic tissue[1] and inflammation. The fact that a perfect gingival margin is unattainable is another reason for remaining clear of the gingival sulcus.

In all sections, some degree of splitting or tearing is noted in the older surface layers of the dental epithelium (Figs. 1 through 13). Normal epithelial proliferation and cytoplasmic degeneration may lead to this commonly found epithelial "tear."[3] The tear usually appears in the region of degenerated cells. It forms a histologic separation of the flattened older epithelial cells leaving what appeared to be "enamel cuticle." With normal epithelial proliferation and cellular degeneration, there may be a loss of cohesiveness between the epithelial cells (loss of intracellular ground substance) resulting in this histologic separation (Fig. 14).

It is well recognized that restorative dental procedures injure the gingival tissues.[1,2,9-20] The response to injury from transient instrumentation to the controls

results in invaginating epithelial buds and cellular infiltration. This injury produced the same proliferation found in the presence of silicate and amalgam restorations. However, the soft tissues soon recovered from the injury sustained during cavity preparation and polishing. This is evident from the tissue repair found in the 30 day control specimens (Figs. 5, 9, and 13).

How does this tissue repair? The nature of this recovery is significant. From this study, while the evidence cannot be considered conclusive, there is a strong suggestion that the epithelial buds return to the original germinal layer.

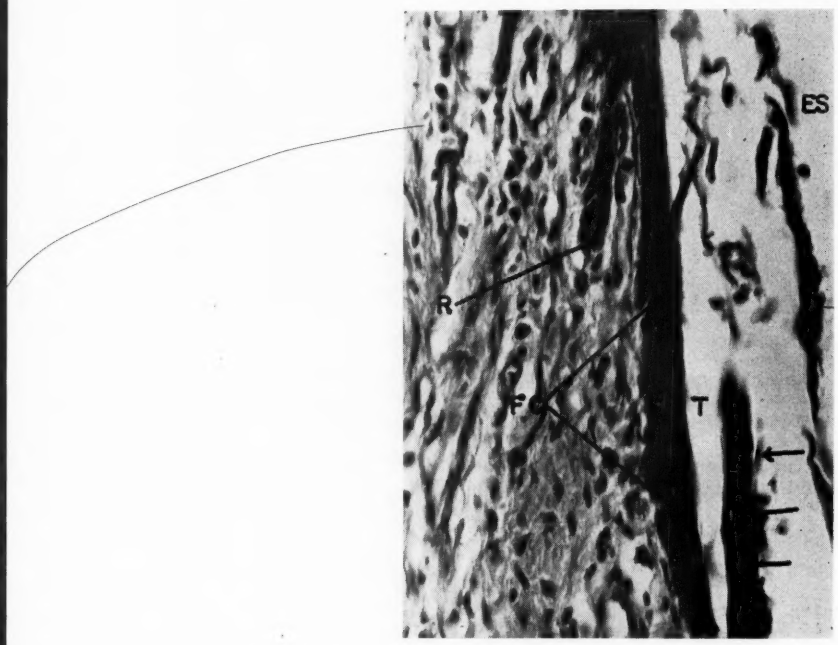


Fig. 14.—A higher magnification of area within the rectangle on Fig. 8: *(R)* round, young cells of budding epithelial proliferation; *(FC)* older, flattened cells of surface layer; *(T)* a tear in the surface layers of the dental epithelium; *(ES)* enamel space. Arrows point to cells demonstrating hydropic degeneration. (Hematoxylin and eosin ×270; reduced ¼.)

SUMMARY

This report verifies the previous findings that silicate and amalgam restorations produce a chronic inflammation of the gingival sulcus epithelium. It also shows that cast gold restorations were well tolerated in the gingival sulcus area.

The physical injury of cavity preparation adds another insult to the soft tissues, as demonstrated by the controls. This injury, however, is repaired within 30 days. The inflammation subsides, and the budding epithelial invaginations into the submucosa apparently subside to the normal microscopic anatomy of the dental epithelium.

The mechanism of this sequence is well suited for future investigation.

Fig. 15.—A section of a human gingival sulcus showing the effects of a calculus deposit on the adjacent soft tissues of the sulcus: *(D)* dentin; *(CM)* cementum; *(DE)* dental epithelium; *(C)* calculus; *(BE)* budding epithelium; *(I)* inflammation. (Hematoxylin and eosin ×35; reduced ¼.)

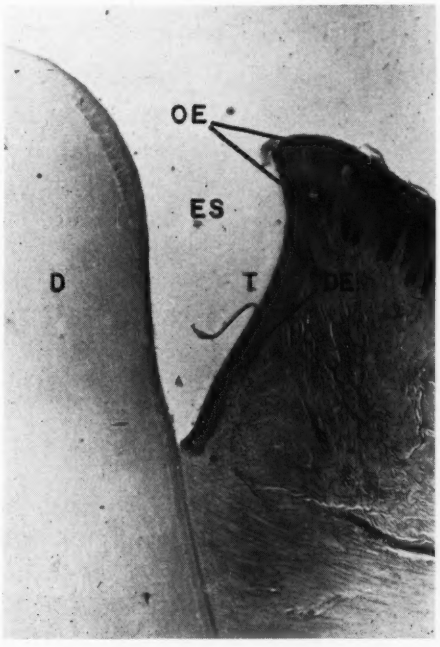


Fig. 16.—Section of the gingival sulcus of a dog; a stainless steel orthodontic band has been in place for 20 days: *(D)* dentin; *(ES)* enamel space; *(DE)* dental epithelium; *(OE)* oral epithelium; *(T)* tear. Note budding epithelial invagination into deeper layers of connective tissue. (Hematoxylin and eosin ×35; reduced ¼.)

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CASTING TECHNIQUES AND SOME VARIABLES

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CASTING PROCEDURES IN DENTISTRY have received wide attention by many investigators. To fulfill the requirements for an ideal restoration, a casting must be made to fit the prepared tooth intimately. Although the goal of perfect reproduction is an ideal for which we strive, it should be recognized that for all practical purposes we can only hope to approach it.

Much has been learned about the principles involved in casting, and probably as many techniques for this procedure have been brought forth through the years as there were people who directed their attention to this problem. Claims have been made that one or another of the methods advocated would produce superior results. This study was therefore undertaken to evaluate several popular casting techniques and to determine if reproducible results could be achieved with these recommended procedures.

METHODS AND MATERIALS

The selection of different techniques and variations used in this preliminary study is outlined in Table I. The casting machines used were selected to represent the different casting forces which are commonly used today. Investment materials utilized were carefully weighed according to manufacturer's directions, and distilled water was used throughout the mixing procedure. Vacuum investing of all wax patterns was employed after they were cleaned with a commercial wax cleaner, and a surface tension–reducing agent was applied to avoid trapping of air bubbles on the surface of the pattern. In all instances, the wax patterns were positioned in the center of the ring and approximately ¼ inch from the end. Two moist asbestos liners were used in each instance, except in the added water technique which utilizes a special ring, rubber liner, and extension ring as described by Peyton.[1]

BURNOUT PROCEDURE

The burnout procedure employed was governed by the specific investment material and technique used. With quartz material or cristobalite where the thermal expansion principle was used, the mold was heated for 1 hour to 1,250° F. prior to casting. The hygroscopic water bath technique utilized a 100° F. water bath for the setting investment for a period of 30 minutes, after which time the mold was slowly

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This study was done at the Indiana University, Graduate School of Dentistry.
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heated for 1 hour to 1,000° F. and then cast. The same temperature was used for the added water technique since the hygroscopic principle is common to both. A special experimental cristobalite* investment having a low setting expansion value was heated up to the same temperature as the regular cristobalite, 1,250° F.

The models used were Bureau of Standards type MOD and full crown steel dies as shown in Figs. 1 and 2. A close-fitting brass sleeve and cap, when fitted over the die, were held together with firm sustained pressure while the wax was adapted to the die. This pressure was obtained by using the force of a spring clip, one jaw engaging the cap end of the assembly and the other end exerting pressure on the base of the die. Fig. 3 illustrates the spring clip, sleeve, and cap. All wax patterns were formed by using molten inlay casting wax which was poured into the previously lubricated and warmed die and collar assembly. The spring force was

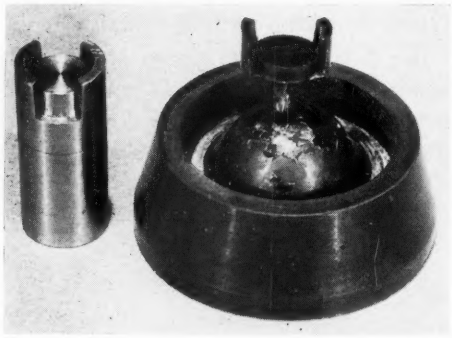

Fig. 1.—The mesio-occlusal–distal steel die and wax pattern.

applied and maintained for 10 minutes before separation to minimize strain in the wax. The greatest number of specimens were of the MOD type, and a 10 gauge sprue was used on the pattern for attachment to the sprue base. The full crown pattern was formed only in the last part of the investigation by use of vertical centrifugal force, and here a 14 gauge wax sprue of a corkscrew design was employed to determine whether a pattern of this magnitude could be cast with accuracy through such a tortuous and narrow opening. Before the wax patterns were removed from the die, they were examined under a binocular microscope to check marginal adaptation. The investing procedure was carried out immediately after the pattern was removed from the die. In the casting operation, the gold† was melted in the casting crucible with the reducing zone of a gas and air blowpipe using a flux consisting of 50 per cent boric acid powder and 50 per cent powdered borax to protect the metal from contamination and to aid in its fluidity.

At the conclusion of the casting procedure, the rings were allowed to bench cool until the evidence of redness disappeared from the button of gold, following which quenching in water was done. The recovered castings were heated in a pick-

*Ransom and Randolph 301-D.
†Ney B-2.

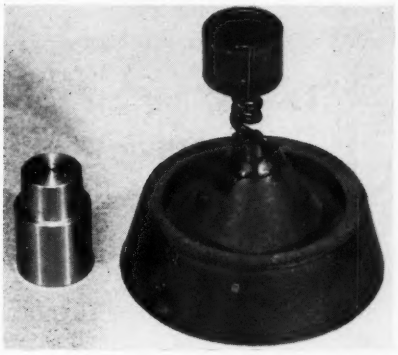

Fig. 2.—The full crown steel die and wax pattern.

ling casserole containing 50 per cent sulfuric acid to remove surface oxides and debris and neutralized by washing under running water. The resultant castings were then carefully examined under the microscope for possible interfering nodules or imperfections before attempting to seat them on the die. A total of thirty castings was made, three for each of the first nine categories, two for the second last, and one for the last.

RESULTS AND OBSERVATIONS

In every category, it was possible to obtain good, clinically acceptable castings. In the categories for which three samples of each were made, none fitted the die with the same measure of precision. Any given casting force or investment or technique did not appear to produce results which were superior to another. The use of sprues of adequate size to assist gold in filling a mold rapidly and completely is a sound procedure, yet a completely formed sharp casting could be obtained where a thin tortuous sprue was used. The position of the sprue in relation to the wax pattern affected the resulting fit of the casting to the die, as did a variation in the amount of water added to the setting investment in the controlled added water technique.

It becomes clearly evident that in dealing with a pattern medium such as wax, problems of distortion resulting from manipulation and temperature changes influence the degree of accuracy of the cast restoration. Whereas uniformity of dimension and thickness of the wax pattern is possible on an experimental die, clinical

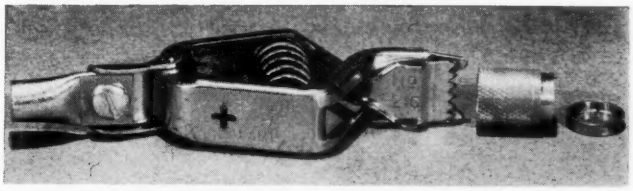

Fig. 3.—The spring clip, sleeve, and cap used for adaptation of the wax to the die.

TABLE I. TECHNIQUES AND VARIATIONS

CASTING TECHNIQUES	INVESTMENT MATERIAL	LINERS	TYPE OF SPRUE	AMOUNT OF WATER (ML.)
Air pressure and vacuum	Whip-Mix Beauty Cast thermal	2	Center	
	Ransom and Randolph 301-D cristobalite thermal	2	Center	
	Kerr cristobalite thermal	2 2	Center Proximal	
	Beauty Cast hygroscopic water bath	2	Center	
Horizontal centrifugal	Peyton's added water hygroscopic; Whip-Mix Hygrotrol	Special ring, rubber liner, and extension ring	Center Center Center Proximal	1.1 1.2 1.3 1.3
Vertical centrifugal and vacuum	Hygroscopic water bath Cristobalite thermal (full crown)		14 gauge	

cavity preparations and wax patterns seldom, if ever, approach such ideal conditions. The distortions thus produced further complicate the problems inherent with wax and make the possibility of obtaining accurate cast reproductions more difficult.

SUMMARY

A very limited study of some casting procedures and techniques was made to try to evaluate these on the basis of reproducibility and superiority. Based on this limited number of samples, it was found that simple techniques or procedures were as capable of producing clinically acceptable dental castings as were more complicated ones. This observation applied equally to materials and casting forces. This study will be expanded to include a larger number of samples and other variables as well as to compare by measurement the amount of variation that exists between samples under a given set of conditions. Sound fundamental principles associated with all aspects of casting must be adhered to, regardless of techniques or materials used. This study should be regarded as a preliminary report.

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DENTAL CERAMICS

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PORCELAIN IS ONE OF THE OLDEST restorative materials used in dentistry. In many ways, its physical properties are comparable to those of enamel. It can be molded, contoured, and fired to any form desired, and its smooth, hard surface makes it compatible with soft tissues. The similarity of the available translucent porcelains to tooth structure makes porcelain restorations inconspicuous.

CLASS III AND CLASS V PORCELAIN INLAYS

Baked porcelain inlays are indicated for conspicuous interproximal cavities in anterior teeth. The cavity preparation is made from the surface with the greatest amount of carious involvement (Fig. 1). If the preparation is made from the labial surface, the retentive factor is established by notching both the porcelain inlay and the cavity walls. This notching provides a mechanical lock between the tooth and the inlay with the cementing medium. If the cavity is prepared from the lingual surface, retentive form is established in the cavity preparation at both the gingival and incisal cavity walls. The incisive functional stress, exerted on the lingual surfaces of the upper anterior teeth, demands retentive form in the cavity as well as the notching of the inlay and cavity walls.

Conspicuous carious involvement of the lower incisors can be treated with class III porcelain inlays if the incisal wall is adequately strong. A weak incisal wall contraindicates the use of this type of restoration.

Gingival caries on the buccal and lingual surfaces of molars can be quite readily restored with porcelain inlays. The compatibility of the soft tissues and glazed porcelain adds to the desirability of this type of restoration.

The retention for class V porcelain inlays must be provided by a mechanical lock. The average knife edge stone is too bulky for grooving small porcelain inlays. However, these stones can be turned down with a heavy diamond stone and made extremely thin (Fig. 2, *A*). Such an instrument used with a copious quantity of water and air is most efficient for cutting grooves in porcelain inlays Fig. 2, *B*). In addition to grooving the side walls, the pulpal surface of the inlay is also well roughened and grooved.

If the end of the cutting blades of a No. ½ or a No. 1 round bur is ground away, an excellent side-cutting bur is produced for notching the side walls of a cavity. The cement between the notches in the inlay and the cavity walls creates the mechanical lock that is the primary factor in retention.

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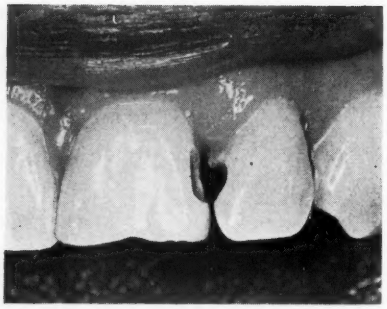
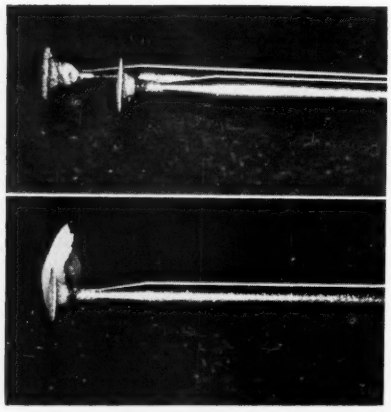


Fig. 1.—Class III preparations. A labial insertion preparation has been made on the central incisor and a lingual insertion preparation on the lateral incisor.

A.



B.

Fig. 2.—*A,* A small, knife edge carborundum stone is compared with a similar stone after it has been thinned down with a large diamond truing stone. *B,* The thinned knife edge stone is used for grooving a porcelain inlay.

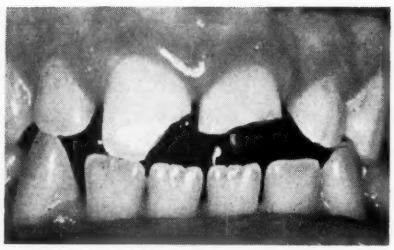
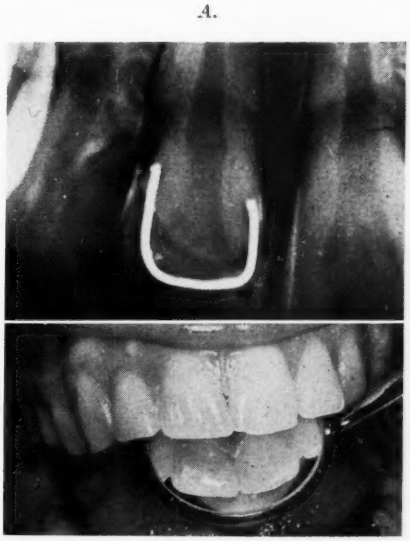


Fig. 3.—Serious fractures of the two central incisors.

Fig. 4.—A 27 gauge dead soft pure platinum wire is used for retention of a class IV baked porcelain inlay.



A.

B.

Fig. 5.—A class IV baked porcelain inlay restores the incisal third of a central incisor. *A*, A 25 gauge threaded irridioplatinum staple is cemented into the gingival cavity walls in both proximal surfaces. *B*, The completed porcelain inlay.

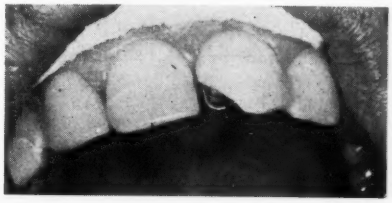


Fig. 6.—A 25 gauge threaded irridioplatinum wire staple is seated in two pinholes, one in the gingival floor and one in the incisal wall of the preparation.

CLASS IV BAKED PORCELAIN INLAYS

The restoration of fractured anterior teeth is one of the perplexing problems in dentistry (Fig. 3). Young people are especially susceptible to such fractures during the growth and development of the dental arches. The unsightly appearance of fractured anterior teeth creates emotional and psychologic complexes in these patients and reflects unfavorably in the development of a young individual's personality.

The shock of traumatic injury may destroy the vitality of the pulp of the tooth. In such cases, the tooth must be treated endodontically prior to initiating restorative treatment.

A fracture may expose the pulp of the tooth. It then becomes necessary to cap the pulp and wait an adequate length of time for secondary dentin regeneration before restorative treatment can be undertaken.

A 27 gauge dead soft pure platinum wire in the incisal area of anterior teeth can be used as a means for retention for class IV baked porcelain inlays (Fig. 4). The platinum wire is used as a loop, and the two free ends are cemented into a pinhole in the incisal third of the preparation at the junction of the lingual plate of enamel and the dentin. The hole is drilled with a No. ½ round bur, and any possibility of encroaching upon the pulp is avoided.

The size of the platinum loop can be contoured to accommodate the space available within the porcelain inlay. Teeth with large pulps, creating a minimum of mesiodistal depth to the cavity, allow little space for the platinum loop. In such instances, the loop can be closed completely by pressing the platinum wires together. The 27 gauge dead soft platinum wire is flexible and easily adapted to the space inside the inlay. The platinum wire should be placed as far incisally as possible to obtain maximum retention for the inlay. The determining factor for this position is to allow just enough thickness of porcelain to withstand functional stress. The center of the proximal part of the inlay should be ground out, prior to placement of the platinum pin, in order to establish a guide for drilling the hole in the incisal portion of the preparation in the tooth. This technique can be used where there is adequate tooth support on both the labial and lingual cavity walls.

Where both the mesial and distal incisal angles have been fractured, a platinum staple can be placed from the gingival cavity wall of one proximal surface to the gingival cavity wall of the other (Fig. 5). This provides a considerable amount of support for the cement and the restoration.

A 25 gauge threaded irridioplatinum wire can be used instead of the 27 gauge dead soft pure platinum wire in most instances. It is used as a staple instead of a loop and is cemented into the gingival floor as well as to the lingual incisal wall of the preparation (Fig. 6). The additional rigidity of the wire, in conjunction with the fixation at both ends of the preparation, adds stability and support to the inlay.

Anterior teeth with fractures at incisal angles should receive retention from the preparation in the central and gingival thirds of the tooth. Therefore, the proximal preparation is most important. The labial and lingual walls should be "boxed" to the maximum extent. It is well to extend the preparation labiolingually as far as possible yet still maintain the box form of the cavity in the proximal region. This affords space for a maximum of porcelain, the platinum staple, and the cementing medium.

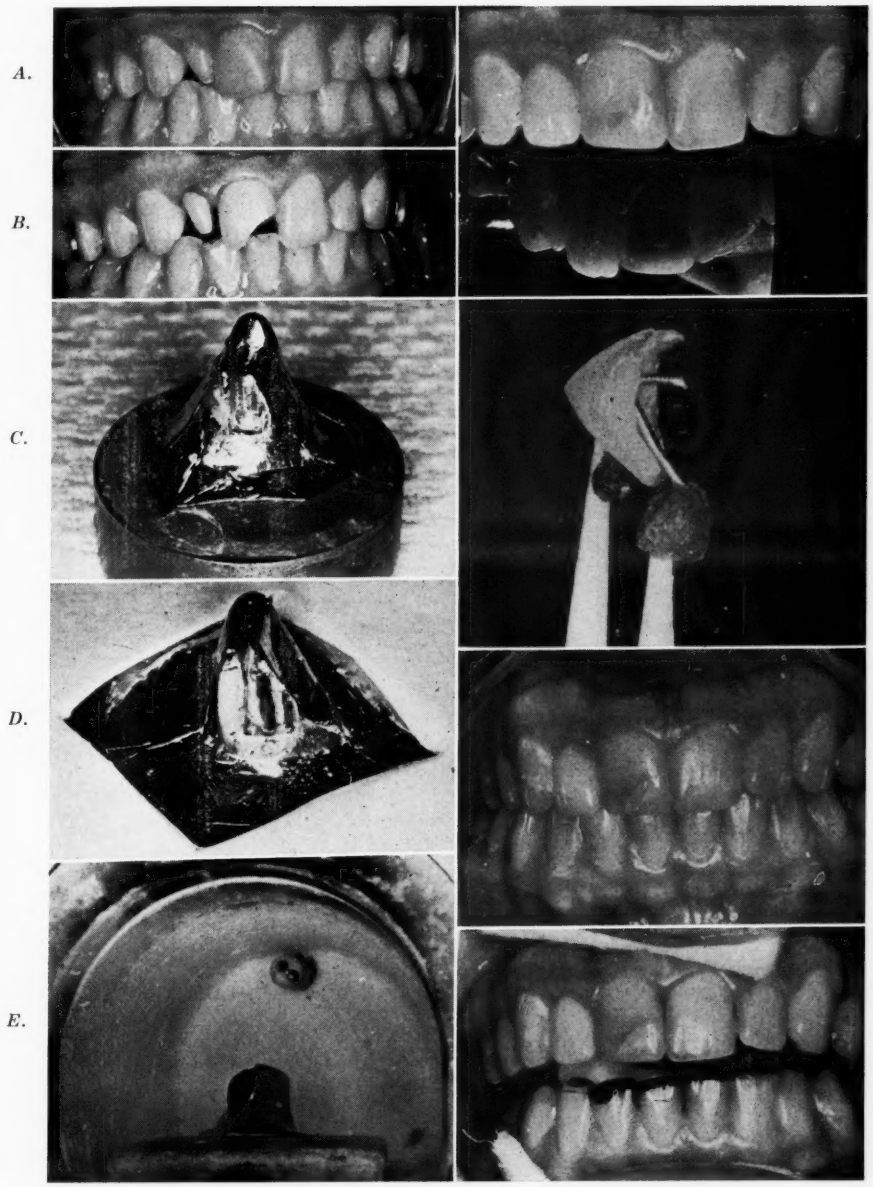
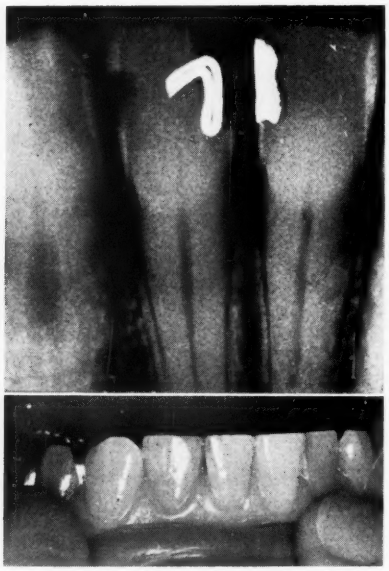


Fig. 7.—Steps in fabrication of a class IV baked porcelain inlay. *A*, A fractured right central incisor covered with a temporary acrylic resin crown. *B*, The preparations of both the fractured central incisor and the peg lateral incisor. *C*, The die is mounted in a swaging cup, and the platinum matrix is adapted. *D*, A wax-impregnated cardboard filler is luted into place in the center of the platinum matrix. *E*, The wax-impregnated cardboard filler inside the first build-up of porcelain is burned out. *F*, The mirror view shows the lingual surface coverage of porcelain on the central incisor. *G*, A 25 gauge threaded irridioplatinum staple acts as a supporting rod inside the prepared groove in the porcelain inlay. *H*, The completed porcelain inlay is on the central incisor, and a full porcelain veneer crown is on the peg lateral incisor. *I*, Prussian blue oil paint thinned with eugenol is painted onto the opposing lower anterior teeth to detect any occlusal imbalance.

FABRICATION OF A CLASS IV BAKED PORCELAIN INLAY

The steps in the procedure of restoring an incisal angle on a central incisor are shown in Fig. 7. The central incisor has an extensive fracture at the mesial angle. There was very little vertical overlap in the anterior part of the mouth. This allowed space for an extra bulk of porcelain in the lingual incisal region. A copper band compound impression of the preparation is made to include the opposite incisal angle and as much of the labial surface of the tooth as possible. This affords the opportunity to measure the dimensions of the porcelain inlay during the fabrication process.

A.



B.

Fig. 8.—*A*, A 27 gauge pure platinum wire loop is used for retention for a class IV porcelain inlay in a lower right lateral incisor. *B*, The lower incisor with excessive labiolingual dimensions showing the completed porcelain inlay.

A Kryptex die is made from the copper band compound impression. It is trimmed to proper contour and mounted with modeling compound in a swaging cup.

The platinum matrix is cut from the four angles, just inside the margins, to the center of the cavity (Fig. 7, *C*). This makes it possible to lay the four flaps down into the cavity without creating tears in the platinum foil covering the margins. The void created by the cuts is then covered with a small platinum patch. A blow torch flame is used to sweat the patch into the platinum matrix. The purpose of the patch is to close the gross opening in the cavity portion of the matrix.

A wax-impregnated cardboard filler (Fig. 7, *D*) placed inside the first porcelain build-up will be burned out and carbonized during the initial firing (Fig. 7, *E*).

A slow gradual burnout of the cardboard will not materially affect the condensation of the porcelain. The first bake will show considerable shrinkage in the porcelain. The porcelain paste should be cut away from the margins at the first build-up to prevent distortion of the platinum matrix during the first firing.

The second build-up and firing should be slightly in excess of the dimensions required for the finished inlay. This accommodates for shrinkage during firing and allows a bulk of porcelain to contour for the final grinding of the inlay. A diagnostic cast can be utilized to calibrate the mesiodistal dimensions of the tooth being restored. The fractured tooth on the diagnostic cast can be waxed to the desired contour and calibrated, or, when this dimension is questionable, the approximating central incisor can be measured to determine the correct size.

If the high biscuit firing has adequate bulk, the inlay is ready for grinding to contour. Soft Joe Dandy disks and carborundum stones are desirable for this purpose. Knife edge carborundum stones can be thinned and used to grind in the necessary surface characteristics of the individual tooth. The character of the surface of the inlay should be harmonious with the surface characteristics of the tooth being restored. A contrast, either in smoothness or irregularity of surface, detracts from a harmonious blending of the inlay with the tooth.

The final firing of any porcelain restoration is most critical. A few seconds of underfiring or overfiring can detract from the final result. The importance of matching the surface characteristics of the tooth is second only to blending the color in the inlay to that of the tooth.

In this example, the centric and eccentric occlusions permitted the lingual surface of the tooth to be covered with porcelain. The porcelain coverage on the lingual surface was carried just to the height of contour of the distolingual marginal ridge. The linguogingival margin of the porcelain was treated just as with a shoulderless jacket crown (Fig. *7, F*).

The bulk of porcelain in the region of the fractured incisal edge was increased over that of the normal labiolingual dimension of the tooth. The extra thickness was not discernible from the labial surface. This increased dimension afforded more space inside the inlay for the platinum staple and supporting cement, as well as for additional thickness of porcelain in this region.

The slot created by the wax-impregnated cardboard filler, in the center of the porcelain inlay, can be enlarged to the proper size with knife edge carborundum stones and very small cylinder diamond stones. These are used in conjunction with a copious stream of water and air. The coolant will prevent the generation of heat and checking of the porcelain.

There should be an adequate thickness of porcelain to seat into the proximal box form in the preparation, but space must be allowed for the platinum staple and the cementing medium. The 25 gauge threaded irridioplatinum wire used with as much bulk of cement as possible provides excellent support for the inlay (Fig. *7, G*). The platinum wire inside the cement is comparable to the steel rods used to reinforce concrete. It adds to the support of the mass.

Small round holes are drilled into the center of the gingival floor and into the incisal region of the tooth, and the irridioplatinum staple is checked for size and

placement. The staple must not interfere with the seating of the inlay. Cementation of the staple and inlay is accomplished simultaneously. The cement is placed into the staple holes with a spiral broach, the irridioplatinum staple is seated into position, both the tooth cavity and the porcelain inlay are filled with cement, and the restoration is seated into place.

A translucent white cement, such as Kryptex, is used for cementation of all porcelain restorations. White does not change the color of the porcelain. The increased labiolingual dimension of the inlay is inconspicuous from the labial view and blends with the natural contour of the teeth (Fig. 7, *H*).

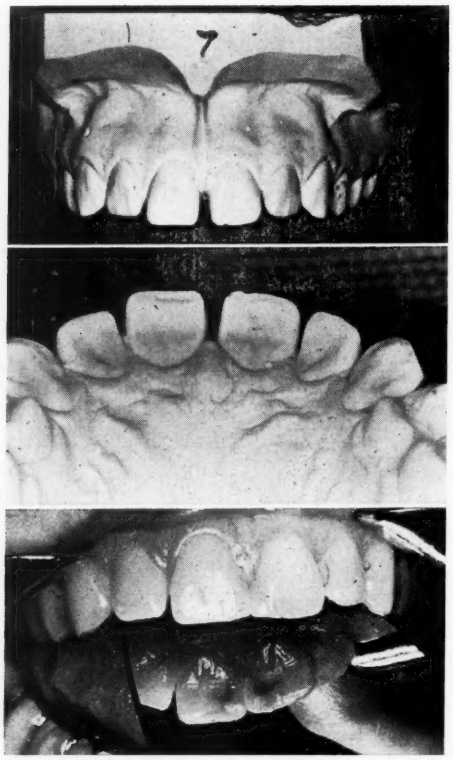


Fig. 9.—*A*, A diagnostic cast with a diastema between the central incisors. *B*, Heavy occlusion on the lingual surface is a displacement factor for class IV porcelain inlays. *C*, The transparent enamel shows the placement of the platinum wire loops.

The labial surfaces of the restorations were made irregular to blend with the normal surface characteristics of the teeth. The natural teeth were characterized by white pigment spots, so the same pigment concentration was placed in the porcelain restorations to achieve a more harmonious blending of the porcelain with the teeth.

The occlusions of the finished restorations must be carefully checked. Prussian blue oil paint, thinned with eugenol, is an excellent pigment for detecting the oc-

clusal contacts with the restorations. The mouth is packed with small cotton rolls or strips of gauze, and the opposing anterior teeth are painted with a thin film of the pigment (Fig. 7, *I*). Then, any excessive occlusal contacts of the lower anterior teeth upon the restorations can be detected and eliminated.

PORCELAIN INLAYS IN LOWER INCISORS

Incisal angles of lower incisors are always extremely difficult to treat because of the small dimensions of these teeth. The mesial angle of the lower right lateral

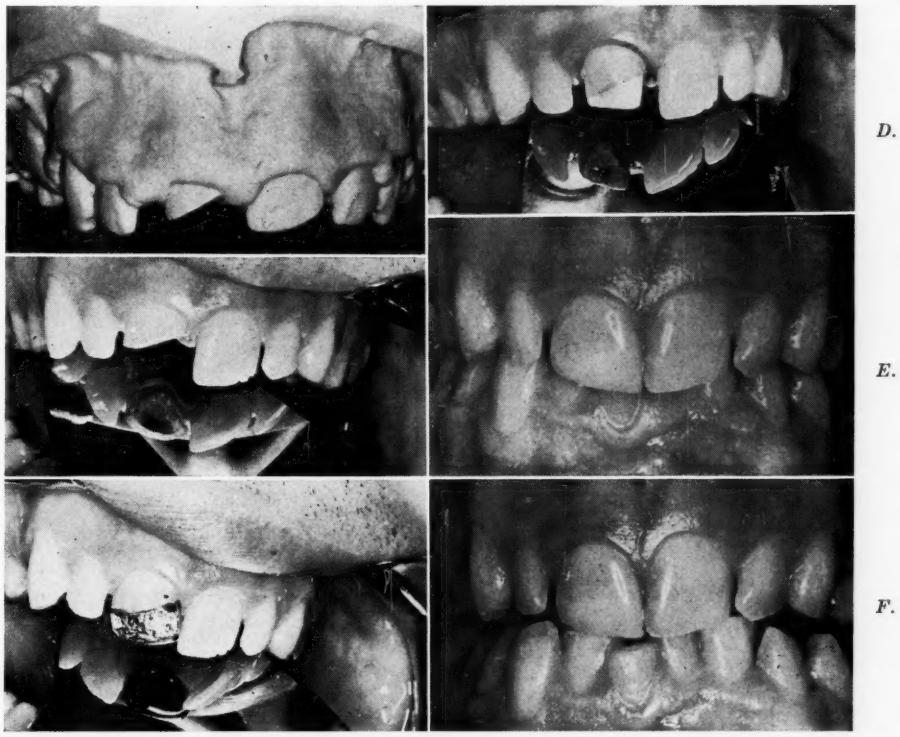


Fig. 10.—A fractured right central incisor of a 13-year-old patient. *B*, The tooth preparation 9 years later. *C*, The pinledge gold casting that was the original restoration. *D*, The basic tooth restoration made with irridioplatinum staples placed in the original pinholes and alloy cement. *E*, The full porcelain veneer crown. *F*, A jacket crown subjected to full occlusal stress.

incisor in Fig. 8 was restored with a class IV porcelain inlay in 1950. The tooth had more than average labiolingual thickness, and this factor contributed to the success of the restoration. The incisive functional stress on these restorations should be carefully examined. Prussian blue oil paint mixed with eugenol and painted onto the opposing teeth will disclose the occlusal contacts. Then, the inlay is ground until it is just out of contact.

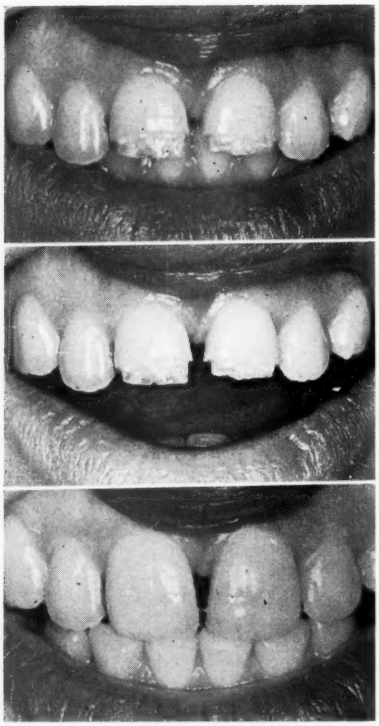


Fig. 11.—*A*, Two upper central incisors disfigured by enamel hypoplasia. *B*, The completed preparations for half jacket crowns. *C*, Completed half jacket porcelain veneer crowns.

ELIMINATION OF A DIASTEMA

A diastema between the two central incisors is an undesirable condition, especially for attractive young women (Fig. 9). Many of these patients desire so much to eliminate this condition that they are willing to have the teeth prepared for full porcelain veneer crowns. However, full porcelain coverage always necessitates maximal tooth reduction, even with the most conservative preparation. Preparations for class IV baked porcelain inlays conserve tooth structure and create less shock to the pulp of teeth.

Fig. 12.—Excessive tooth reduction in preparations for full porcelain coverage.

A diagnostic cast will reveal the extent of the diastema and the tooth abrasion as a result of occlusion with the lower incisors (Fig. 9, *B*). Excessive stress on the lingual surfaces of the teeth to be restored presents a displacement factor and can cause the failure of the restorations. The occlusion must be carefully analyzed and equilibrated before tooth reduction is begun. The occlusal contacts must be limited to natural tooth structure and must not be made on the porcelain inlays.

Sometimes, the esthetic result is not the best if the approximating teeth are brought into contact. Rounding the mesiolabial marginal angles of the inlays, leaving an almost imperceptible space between the teeth, is often preferable. A simple way to predetermine the correct contour is to use a soft, light yellow wax directly on the teeth in the mouth and determine the most desirable esthetic contours.

Platinum wire loops cemented into the lingual incisal region of the central incisors are used for retention of class IV porcelain inlays (Fig. 9, *C*). The lingual plate of enamel was denuded of dentin so the platinum wire could be placed against the enamel and thus prevent the pinholes from endangering the pulp.

EXTENSIVE TOOTH FRACTURE IN YOUNG PATIENTS

Fractured teeth of young patients require protection without endangering the pulps until the pulps are small enough to make permanent restorations possible. A 13-year-old patient had broken the right central incisor, but there was no pulp involvement. The tooth was given conservative restorative treatment (Fig. 10). The

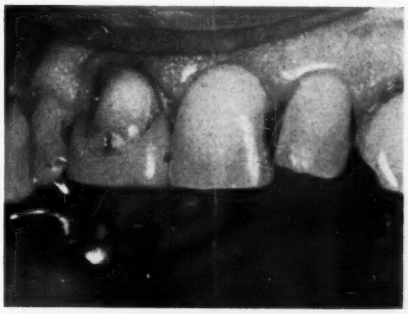


Fig. 13.—The labial crescent-shaped fracture was caused by a lack of tooth support for the porcelain.

preparation consisted of three pinholes, one mesial to the pulp, one distal to the pulp, and one in the cingulum. A pinledge gold casting with a baked porcelain inlay was the temporary restorative treatment (Fig. 10, *C*). This served 9 years.

The gold crown was removed, and roentgenograms showed adequate recession of the pulp for more definitive treatment. Irridioplatinum staples were placed in the pinholes used for the previous restoration, and the tooth was built up to a more adequate shape and contour with alloy cement (Fig. 10, *D*).

An irridioplatinum staple was placed from the cingulum pinhole to the mesial pinhole, and an irridioplatinum pin was placed from the distal pinhole to the under-

surface of the cingulum-mesial staple. The irridioplatinum wires provided the support for the alloy cement base. The tooth was prepared for a full porcelain veneer crown. A chamfer finishing line was used at the labiogingival margin instead of a shoulder preparation. This conserved much tooth structure and enabled the porcelain to be placed at the labiogingival margin in the same relation as tooth enamel.

The stress on the tooth in the protrusive occlusion was severe. The support to the tooth provided by the platinum staples and alloy cement base enhanced the life expectancy of the porcelain crown.

Whenever possible, it is desirable to reduce the height of the opposing lower anterior teeth to a more even distribution of stress over a maximum number of the anterior teeth. The steep vertical overlap prevented any assistance from the occlusion in the posterior part of the mouth when the teeth were in a position for incision.

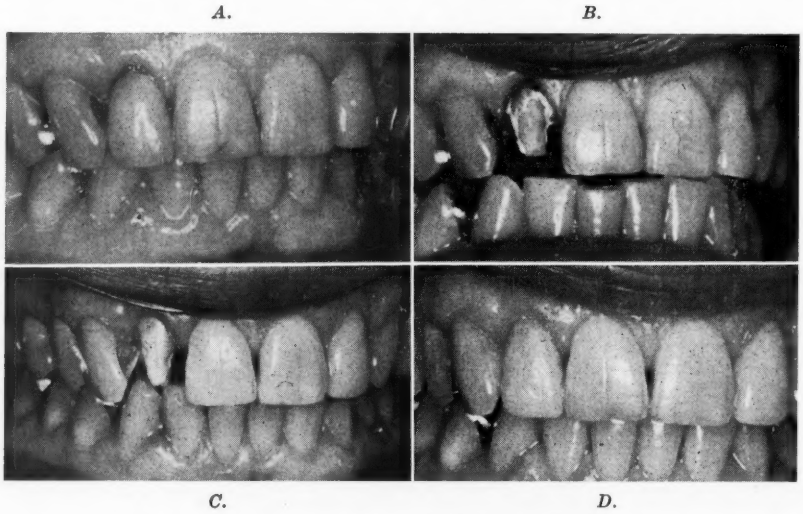


Fig. 14.—*A*, Gingival tissue recession and carious involvement at the labiogingival margin of a porcelain jacket crown. *B*, There was excessive tooth reduction in all dimensions. *C*, The cuspid has been prepared for a porcelain inlay, and a shoulderless crown preparation has been made on the lateral incisor. *D*, The completed restorations.

HYPOPLASTIC ENAMEL

Hypoplasia often disfigures the enamel of anterior teeth (Fig. 11). This defect can be treated by half jacket crowns. The objectives are to conserve tooth structure and create minimal shock to the pulp. The cavity preparation consists of little more than forming a shoulder around the defective surfaces of the teeth and providing just enough clearance for an adequate amount of porcelain at the labioincisal angle (Fig. 11, *B*).

It is imperative that the labial shoulder in the preparation be made at right angles to labial surface to prevent shadow effects in the porcelain (Fig. 11, *C*). It the shoulder is prepared at an obtuse angle, the labial margin is conspicuous. This is caused by the varying degree of thickness of the porcelain at the labial margin.

These half jacket crowns are stronger and less subject to fracture than full length jacket crowns. This is due to the resistance which is provided by the incisal

A. *B.*

Fig. 15.—*A*, A chamfer preparation made at the labiogingival margin demonstrates that tooth reduction can be kept to a minimum. *B*, The porcelain covers the tooth just as the enamel had covered it.

third of the tooth (Fig. 11, *C*). The most common fractures of full porcelain crowns occur at the labiogingival or the linguogingival regions of the crowns.

FULL PORCELAIN VENEER CROWNS

Teeth prepared for full porcelain coverage *may* be endangered by excessive tooth reduction (Fig. 12). The vitality of the teeth in this situation is jeopardized, and the all important tooth support for the porcelain veneer is destroyed. The only effect gained by excessive tooth reduction is space for a bulk of porcelain. Such

A. *B.*

C. *D.*

Fig. 16.—Excessive attrition and erosion of anterior teeth. *A*, Preparations were first made on right lateral and left central incisors. *B*, The completed jacket crowns are cemented into place. Then, the right central and left lateral incisors are prepared. *C*, Full occlusal stress was exerted on the jacket crowns. *D*, The upper left fixed partial denture was rebuilt to produce better posterior occlusion and to increase the life expectancy of the jacket crowns.

preparations express a complete lack of understanding of the basic requirements of tooth preparation for full porcelain veneer crowns.

Crescent-shaped fractures of the labial surface of crowns are invariably caused by an insufficient length of the preparation at the labioincisal edge. Functional stress without tooth support is like a lever arm suspended from a fulcrum point. The resultant stress is radiated behind the fulcrum point, and in the central incisor in Fig. 13, it is at the labiogingival edge. The veneer crown was between 2 and 3 mm. thick. The density of the porcelain was good. The only logical reasons for the fracture were inadequate tooth support for the porcelain and stress that exceeded the limit of tolerance.

A shoulder preparation at the labiogingival margin creates an abutted joint of the porcelain with the tooth. It is extremely difficult to fabricate a porcelain jacket crown that will have a perfect union of porcelain and tooth. Often, the porcelain will project beyond the margin of the shoulder and irritate the gingival tissue. As a result, the soft tissue recedes from the margin of the crown and exposes the root, which decays (Fig. 14, *A*). When this crown was removed, excessive tooth reduction in all dimensions was revealed (Fig. 14, *B*). A greater length of tooth should have been retained at the labioincisal edge.

To correct this situation, the labiogingival margin of the preparation is extended to include the carious area, and a chamfer finishing line was made to replace the shoulder preparation (Fig. 14, *C* and *D*). A full porcelain veneer crown was placed on the lateral incisor. Interocclusal stress must be equilibrated over a maximum number of the opposing teeth in an endeavor to offset the lack of internal tooth support for the porcelain crown.

LABIAL CHAMFER

Tooth reduction on the labial surface can be minimized by making preparations with a labial chamfer (Fig. 15, *A*). This type of preparation requires less tooth reduction and creates less shock to the pulp. The porcelain veneer crown is placed over the tooth just as the enamel had been (Fig. 15, *B*). As a result, the gingival tissue will seek the protection of the glazed porcelain instead of receding from it. The natural adaptation of the porcelain to the tooth creates a better appearance, and it establishes a more healthy environment for the gingivae.

The lack of tooth reduction in the labiogingival region is compensated by increasing the thickness of the porcelain in this region. The minimum increase in thickness is 0.5 mm. This is inconspicuous and adds to the protection of the gingival tissue.

When several anterior teeth must be restored, the preparations should be made first on one central incisor and one lateral incisor (Fig. 16). The approximating teeth serve as a guide for both the position and the dimensions of the restorations. After these restorations are cemented into place, the other central and lateral incisors can be prepared. The first two completed restorations then are the guides for position and dimensions of the second two veneer crowns. This procedure simplifies restorative work and enables the dentist to position and contour veneer crowns more accurately.

The posterior occlusion should be restored to protect the crowns on the anterior teeth and increase their life expectancy (Fig. 16, *D*).

Maximal tooth support is essential for the protection of porcelain restorations from fracture under heavy functional stress.

CONCLUSION

The life and health of the natural teeth should be maintained through conservative tooth reduction and maximal protection of the vitality of the pulp.

Porcelain is an excellent restorative material. Its tendency to fracture under excessive tipping stress is offset by the very favorable esthetic results that can be obtained by the proper fabrication of restorations. Dental porcelain, properly contoured and glazed, is unsurpassed in compatibility with the gingival tissues.

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UNIVERSITY OF MICHIGAN

RESEARCH

REPORT OF THE COMMITTEE ON SCIENTIFIC INVESTIGATION OF THE AMERICAN ACADEMY OF RESTORATIVE DENTISTRY*

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RESEARCH ACTIVITY IN DENTISTRY is compounding itself so rapidly that existing concepts are soon outmoded. However, the greatest obstacle to an intelligent appraisal of the past year's research is the necessity of limiting this review to studies which have some obvious dental application. It is the pure research in sciences such as chemistry, physiology, and microbiology that will shape the destiny of dentistry more than the investigations which have been directly applied to dental problems. The reviewer can take some solace in the thought that no individual or group of individuals is qualified to predict which investigation or field of study of the year 1960 will eventually prove to be of unusual significance to dentistry.

SURVEY OF DENTISTRY

It is possible that the most significant single achievement of the year was not a research report of the conventional type but rather the completion of the 2 year survey by the Commission on the Survey of Dentistry in the United States. The final report is now available,[1] and it deserves serious reading by any dentist, educator, or scientist who is concerned with the future of this profession. Dr. Volker and I worked with the research committee of this survey, and although we are intimately aware of some of its frailties, I am sure he would agree with me that certain of the findings should be cited in this review. For example, although the expenditures for dental research now exceed $10,000,000 annually, they still represent only one-fiftieth of the amount spent on the total health research effort, even though annual expenditures for dental treatment represent 10 per cent of the health care budget of the American public.

As might be anticipated, of the 1,026 known investigations in 1958, approximately 30 per cent were concentrated in the three areas of caries, dental materials,

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and periodontal disease, with studies on erosion and calculus sorely neglected. Many other important, broad research areas related to dental health are as yet unexplored, such as psychologic and psychiatric research, neurophysiologic studies, investigations into the mechanisms of speech and phonetics, diet and nutrition in relation to the senses of taste and smell, aging of oral structures, and educational research. The general tone of the survey, however, indicates that the major problem facing dentistry is not so much the lack of adequate investigation in certain neglected areas, but rather it is the acute shortage of research personnel and the inadequate training programs for the highly specialized fields of dental research. The data support this view. For example, only 7 per cent of all principal investigators spend their full time in research. The Commission further points out the tendency to splinter the efforts of investigators so that what is often visualized as a concentrated attack on a specific problem may be greatly diluted. It is well illustrated by the example of one investigator reporting responsibilities for thirty-five separate projects.

Another significant finding is the noticeable lack of technicians needed to assist in effective research. In most scientific fields, a ratio of three or four technicians for each professional person is regarded as desirable. The ratio in dental research is on the order of only one-half technician per investigator. The impression left then, and it would seem to be logically deduced, is that the shortage of personnel and of programs for training such individuals is more acute than is the need to increase physical facilities.

A secondary conclusion that might be deduced (one which has been indicated in surveys by the United States Public Health Service of their extramural program) is that greater effort must be expended to use scientists already trained but not now being employed by dentistry. The oral mechanism and its relationship to the rest of the body cannot be separated. Therefore, the training of individuals who may concern themselves with the special research aspects pertaining to the oral cavity is as important to the health of the American people as the training of specialists in any of the other health fields.

The other sections of the survey devoted to dental health, practice, and education are also noteworthy.

It is true that the final recommendations of the Commission are not particularly imaginative and do not suggest the exact means for implementation, but this is not the direct responsibility of those making the survey. The report merely depicts where the profession has been, the direction it is moving, and where it must go to accomplish its goals. This the Commission has done with surprising clarity and efficiency. The profession is now aware of its responsibilities and has a yardstick for measuring its progress.

CARIES

The control of dental caries must still be recognized as the most important problem in dental research.

Significant progress was made during 1960 in our understanding of the prevention of dental caries, with primary contributions coming from both the clinical

and basic science areas. One of the more significant accomplishments in the former category is that relating to the use of stannous fluoride in the prophylaxis of dental caries, while the most important reports in the latter classification are on the research studies indicating the infectious nature of dental caries in experimental animals. Because both of these areas of research had previously been unstable and controversial, these works represent milestones in caries research and deserve special mention.

In an unprecedented action, the Council on Dental Therapeutics of the American Dental Association[2] recognized the usefulness of a commercial dentifrice as a caries preventive agent and classified it in group B. Because of this unusual action, it is timely to emphasize the exact status of group B products. According to the Council on Dental Therapeutics:

> Listing of products in Group B means that there is insufficient evidence to justify their present acceptance, but there is reasonable evidence of their usefulness and safety. These products meet the other qualifications and standards established by the Council on Dental Therapeutics.
>
> The council's initial consideration of products which may be eligible for Group B listing is influenced favorably by the knowledge of further investigations then in progress. It is the policy of the Council to reconsider Group B products each year on the basis of new evidence which may be produced in their support.

This particular dentifrice contains 0.5 per cent stannous fluoride, 39 per cent calcium pyrophosphate, 30 per cent glycerin, 1 per cent stannous pyrophosphate, plus water and miscellaneous formulating agents. At the time of its Council acceptance, seven clinical tests had been conducted, and all were in agreement that the therapeutic dentifrice was of assistance in controlling tooth decay. It should, however, be emphasized that none of these studies have been conducted in areas where the drinking water contained appreciable levels of fluoride and that the maximum length of the studies was 2 years.

Water Fluoridation.—Although all of these data point to certain value of stannous fluoride, both as a dentifrice ingredient and as a topical agent, in the prophylaxis of dental caries, it is obvious that this evaluation must be continued and expanded. Under no circumstances should it be thought of as a substitute for water fluoridation. It is unfortunate that the fluoridation of public water supplies as a means of limiting dental caries continues to receive vigorous public opposition. As a consequence, the number of new communities adding fluoride to their water during the year was disappointingly few. Cities reporting water fluoridation results of 13 or more years' duration now include Grand Rapids, Michigan; Newburg, New York; Brantford, Ontario; and Evanston, Illinois. All of them are in substantial agreement that the therapy is of great value. It has been calculated that in the city of Evanston alone, during the first decade 11,000 school children were spared 30,250 carious teeth.[3] Based on current dental fees, this represents a saving of $242,000. It should be emphasized that in none of the long-term studies has there been evidence of increased pathologic occurrence in any age group.

Investigations into the basic mechanism by which fluorides limit dental caries reveal a previously unsuspected property.[4] Whereas it has been known that partially

decalcified enamel can be rehardened by exposure to solutions of soluble calcium phosphates, this reaction proceeds slowly. When very small quantities of fluoride are added, the action is greatly accelerated. This finding suggests that in addition to strengthening the acid resistance of enamel, fluoride may benefit teeth by promoting recalcification of the initial lesion.

Infectious Process of Caries.—In the middle of the last decade, it was demonstrated that caries susceptible strains of animals could ingest a high carbohydrate diet without developing tooth decay if they were maintained in a germ-free environment. It was also shown that these same germ-free rats could be inoculated with specific microorganisms and experimental caries invariably resulted. Although these observations demonstrated very clearly the basic role of microorganisms in the causation of tooth decay, they did not clarify our understanding of the infectiousness of the process under more normal conditions. The latter phenomenon has been studied intensively during the last year.

It has been reported that dental caries in both rats and hamsters is an infectious and transmissible disease.[5] The causative bacteria are penicillin sensitive. If such bacteria are present, or inoculated into young animals, rapid dental caries develops within 35 days after they have been placed on a high carbohydrate, low fat diet. The phenomenon has been studied under a variety of conditions. If young hamsters from a stock having mild caries activity are divided into two comparable groups, one remaining isolated and the other caged with animals from a caries active stock, the number of carious teeth in the latter group is increased more than 100 per cent. Even greater differences are observed in the relative extent of tooth destruction between the two groups.

The evidence suggests that the transmission of the cariogenic bacteria results primarily from feces ingestion. This belief is substantiated by experiments in which caries activity has been induced in caries inactive hamsters by inoculation with feces from caries active hamsters. The inoculation has been accomplished by either intraoral smear or contamination of drinking water. Regardless of the mode of transmission, there was a dramatic increase in dental caries in animals with a previous record of low caries activity. When the penicillin sensitive bacteria of caries active female breeders were depressed with antibiotics, there was almost a complete loss of caries activity in the offspring.

Studies have been undertaken of the etiologic roles of specific microorganisms in experimental caries.[6] Streptococcal, diphtheriod, and lactobacilli strains have been introduced into the oral cavity by swabbing or pipetting. Although caries inactive animals infected with mixed cultures of lactobacilli and diphtheroid organisms failed to develop dental caries, those receiving streptococci developed tooth decay similar to that observed in caries active animals. The cariogenic strains of streptococci which were administered to experimental animals could be recovered from carious lesions and the feces. Although the pertinence of these observations to human dental caries is not clear, it is obvious that they add considerably to our knowledge of the etiologic background of the disease.

Other Factors.—In addition to the major accomplishments, certain other studies may have ultimate significance in preventing tooth decay. Laboratory and

clinical studies suggest that certain agents may increase dental caries susceptibility. It has been noted[7] that the dental caries attack rates of teeth were significantly higher in areas where the element selenium was present in the diet.

It has also been reported that immature rats maintained on stock rations and drinking water with 1 to 1.5 per cent hydrogen peroxide developed extensive dental caries within an 8 week period. Similar effects occur when zinc peroxide and sodium perborate are incorporated in the diet at a 2 per cent level.[8] Although it is probable that neither of these observations is of great significance in the epidemiology of human caries, they are illustrative of the multitude of factors that may allow some alteration in the caries patterns of individuals or groups.

Investigations of the role of dietary phosphate in dental caries limitation are continuing. Metaphosphoric acid has been added to a group of substances that may have value as cariostatic agents. Experimental animals fed a cariogenic diet containing 1.36 per cent metaphosphoric acid are reported to have developed 70 per cent less caries than their controls.[9] Data by Bibby[10] have also pointed out that the presence of milk products or calcium phosphate reduces decalcification even though large quantities of acid are present. At least two large scale clinical experiments testing the effects of added dietary phosphates on dental caries are now in progress, and their results are awaited with anticipation by investigators.

Evidence continues to accumulate slowly that the hexitols may be of some value in the dietary control of dental caries. These sugar-related compounds resist fermentation by oral microorganisms. It has been reported that when they are substituted for sucrose or dextrin to the extent of 20 per cent or more in a cariogenic diet, there is a moderate but consistent reduction in caries experience. Greater amounts seem contraindicated since they induce diarrhea.[11]

The value of caries susceptibility tests in estimating caries activity has been questioned by a recent study.[12] Little correlation was found with the number of new carious surfaces observed over 6 to 12 months in children and their lactobacilli count and Snyder test and Rickles test reactions during this interval.

Although it is generally agreed that increased salivary flow is of benefit in limiting tooth decay, very little information is available as to the other factors associated with increased salivation. Recently, researchers have investigated the effect on salivary flow for periods up to 130 minutes of application to the tongue of optimal concentrations of acid (citric acid), salt (sodium chloride), sweet (sucrose), or bitter (quinine) tastes. Although all these substances stimulated salivary flow, the greatest response resulted from citric acid and sodium chloride.[13] It is conceivable that continuation of these experiments could result in the formulation of therapeutic agents that would be beneficial in the control of dental caries simply by accelerating oral food clearance.

As this report was in preparation, encouraging findings were announced for a new anticaries dentifrice. Preliminary clinical studies have shown that 1 year of use of a dental cream containing tetradecylamine acetate resulted in a 44 per cent reduction in caries in 13- and 14-year-old school boys. It is pertinent that the dentifrice was used under unsupervised conditions. The agent is believed to exert its effect by covering the wet enamel surface with an acid-resisting film. The clinical studies follow almost 10 years of continuous laboratory investigations in this field.[14]

This suggested mechanism of producing some type of a protective covering for the enamel surface has been pursued in another unrelated investigation. It is generally recognized that foods which are rapidly cleared from the oral cavity, such as liquids, do not have as high a caries-producing potential as those which tend to remain in the mouth longer, even though the carbohydrate content is comparable. Thus a test method has been developed to assess the adhesive qualities of various foodstuffs.[15] In the future, it is possible that a means of decreasing the tenacity of certain foods may be suggested by these studies. Somewhat in this same vein are investigations[16] beamed toward development of moisture repellent coatings for application to teeth. Such a coating could undoubtedly reduce the adhesion of foods to the tooth surfaces and also prevent attack by acids.

Another phase of the caries problem in which there has been considerable interest during the past year is the effect of the various types of foodstuffs that are taken into oral cavity on the production of caries. Bibby[10] cites both past and current research which indicates that not only is the amount and the frequency with which carbohydrates are consumed an important factor in dental caries but that the form of the carbohydrate is pertinent as well. Data are presented which indicate that the acid-producing ability of a particular food is not necessarily indicative of the degree to which it will decalcify tooth tissue.

MATERIALS AND INSTRUMENTATION

Marginal Leakage.—Research devoted to the problem of marginal leakage around restorative and endodontic materials continues to expand,[17-20] with a wide variety of labeled isotopes and dyes now being employed to study the phenomenon. Although many new variables are now under investigation, no evidence has been presented to change the observation made last year,[21] that as yet there appears to be no such thing as the "hermetically sealed" restoration. The existing knowledge seems to lead to no other conclusion but that leakage, minute or gross, is an everyday phenomenon and that a certain percentage of the failures previously attributed to other factors may be traced to gross leakage of deleterious agents, such as acids of small molecular size.

However, it is well to repeat that the exact clinical significance of this in vitro test has yet to be proved. The research has demonstrated the phenomenon, and continued study may eventually define the limits permissible. In spite of certain claims that have been made, I must report that the year 1960 brought no significant advancements in the development of a filling material or cement that would chemically bond to either enamel or dentin.

The demonstration of the phenomenon of marginal leakage has spurred research on the antibacterial characteristics of restorative materials. The two are intimately related. It has now been clearly established[22,23] that the unique anticariogenic characteristics of silicate cement may be attributed to fluoride uptake by the adjoining tooth structure, resulting in lower enamel solubility. The mechanism has now been carried over to at least one commercial resin by the addition of a low concentration of sodium fluoride.

Incorporation of fluorides, glass fibers, or any other additive agents in an attempt to improve certain physical properties of dental restorative materials has increased the need for proper biologic evaluation. Research by Mitchell,[24] utilizing implantation of pellets of the material subdermally in the rat, reveals that the additive agents may have a profound effect on the normal irritational characteristics of a given material. For example, the addition of silver or copper salts or of polyantibiotics to zinc phosphate cement markedly increases tissue response.

Recent studies[25] have also emphasized the dominant role of the dentin in protecting the pulp from the restorative material. For example, whenever dentin thickness is less than 100 μ, irritation from an acid cement is markedly increased.

Pulp Exposures.—It has long been known that the marginal blood vessels in the pulp close to dentin are capillary in size and in any deep cavity preparation the possibility of microscopic pulp exposure can always exist without evidence of hemorrhage. This research has been revived by Mohammed,[26] who has shown that such exposures may be undetected with no clinical symptoms even when viewed at twenty-five power magnification. Since these minute exposures could admit acid or other deleterious agents, it would seem logical that until dentistry has developed a more precise method for detecting pulp exposures clinically, every deep cavity preparation should be considered as a possible pulp exposure.

Cavity Liners.—Cavity liners have been allotted a just share of the research effort.[27-29] Soon, their role in operative dentistry will not be based on empiricism alone. Although the ability of liners and varnishes to inhibit acid penetration is dependent upon composition and the presence of a continuous coating, the evidence suggests that, in general, most products do afford some measure of protection to the dentin, and thus the pulp, against acids such as phosphoric. Further research is indicated to determine the exact pH of a cement at the time when the acid finally penetrates the liner and whether that specific pH produces an irreversible reaction in the pulp.

Time does not permit further citation of the myriad research in this area,[30] such as the increasing interest in zinc oxide–eugenol as a permanent cement,[31] clinical substantiation of the exact relationship of mercury to the amalgam restoration and of cavity design to the incidence of fracture,[32,33] continued investigation of the dimensional changes occurring in the wax pattern during normal setting and hydroscopic expansion of the investment,[34,35] and the research of Woelfel and Paffenbarger, who have established that the dimensional change of the artificial denture after 2 years in the mouth is in the order of only 0.1 to 0.3 per cent, regardless of the resin composition or the technique of processing.[36]

Instruments and Rotational Speeds.—The past year has finally brought a reprieve from the annual deluge of new cutting tools and operational speeds. A plateau has been reached, and dentistry can rationally study and assimilate the techniques that are now accepted into dental practice. While research emphasis is now concentrated on tissue response to cavity preparation, significant progress has been made on standardization of the sorely neglected area of instrumentation—that of the cutting tool itself. A tentative specification covering steel and carbide burs and diamond stones has been formulated. Its final acceptance by the American

Dental Association will aid greatly in standardizing size, cutting efficiency, numbering systems, and endurance of these tools.

The depth of the cavity plays a dominant role in tissue irritation, regardless of revolutions per minute or mode of cutting. When in close apposition to the plup, injury from any method of cavity preparation may be greater than originally believed.[37]

The work of Stanley and Swedlow[38] indicates that coolants do not minimize inflammatory responses when the operative technique makes use of pressures above 8 ounces. On the subject of coolants, the research of Schuchard and Watkins* is of special interest, since it cast some doubt on previous studies related to the importance of using water or water vapor during high speed cutting. Their work indicates a possible drop in the surface temperature of the tooth when cut with turbines using air as a coolant. However, the desiccating effect of air has not been adequately investigated. This entire aspect of operative dentistry, covering theoretic and practical considerations, has been nicely analyzed by Stebner.[39]

A recent questionnaire submitted by Petray† to fifty-five dentists in the San Francisco area corroborates research studies in regard to the effect of ultra high speed on patient acceptance, noise, pulpal injury, operator efficiency, and visibility. These observations stress the fact that while higher speeds are most acceptable biologically and mechanically, they require alertness and demand respect from the dentist.

A report by Cantwell[40] on noise level measurements made with two popular high speed handpieces indicates that neither the patient nor the dentist can expect loss of hearing as a result of the noise level of either of the two instruments tested. Temporary threshold shifts may occur, but they could not be considered a hazard.

PERIODONTOLOGY AND OCCLUSION‡

There is the general belief among many dentists that there is little research activity in the field of periodontology. Actually, in relation to the volume of research which has been conducted on dental caries, this is true. However, it is estimated that over $1,000,000 was assigned to research projects on specific problems in periodontology in 1957 (the last year for which figures are available) and over $1,000,000 additional was allocated to research projects which had definite applications to periodontology.[41]

Calculus Deposition.—Since calculus deposition is one of the most important locally irritating factors in periodontitis, it is natural that the problems associated with calculus deposition have been carefully studied. It has been stated that calculus deposition is due, in part at least, to bacterial action. Certain of the thread-forming oral microorganisms (often identified as Leptotrichia) serve as a framework or nidus for the deposition of the inorganic salts from saliva. It is possible also that some of the metabolic products of certain bacteria may play a role in calcium deposits in bacterial plaques. However studies recently reported by Baer and Newton[42]

*A. Shuchard and E. C. Watkins: Personal communication.
†H. Petray: Personal communication.
‡In consultation, Dr. M. K. Hine analyzed certain of the literature cited in this section.

indicate that deposits of calculus have been found in germ-free mice. The onset of periodontal disease in these animals was detected in 44 per cent of the animals examined between the third and fourth months of the experiment, and all mice had considerable alveolar bone loss at the end of 6 months. Hard calculus deposits were observed on the enamel surfaces of the molar teeth in thirty of the thirty-eight animals which were fed a standard diet. The fact that calculus can be found in germ-free animals does not, of course, preclude the possibility that calculus in humans may be dependent on bacterial action, at least in part. Nevertheless, these findings indicate the desirability of continued study and re-evaluation of problems associated with calculus deposition.

A study reported by Stewart and Burnett[43] indicated that there is a relationship between certain dietary factors and the formation of a calculus-like deposit in albino rats. These authors reported that increasing the protein content of the diet increased the rate of formation and amount of calculus accumulating in these animals. Of course, the relationship between food intake and calculus deposition has long been suspected. G. V. Black reported that calculus was deposited after the "ingestion of an excess amount of almost any food."[44] Incidentally, Stewart and Burnett[43] also reported that the addition of sodium bicarbonate to the diet of rats increased the rate of formation of calculus. This research makes one wonder if dentists should not be more careful in recommending that sodium bicarbonate be used as a dentifrice. No reports are known of adequate clinical tests on the use of baking soda as a dentifrice, and it is entirely logical to assume that an alkaline environment would encourage deposition.

Jordan, Fitzgerald, and Faber[45] reported extensive calcareous deposits in a rat receiving a noncariogenic diet consisting primarily of cornstarch and milk powder, with some yeast, cod liver oil, and salt mixture added. Fitzgerald and associates[46] pursued this research with rats on a similar diet but added certain antibiotics. They found that in every animal receiving the special diet, hard calcareous deposits were noted. In the rats receiving antibiotics, calculus deposits were also found. If bacteria are responsible for calculus deposition, they must be microorganisms which are not affected by the antibiotics used in these experiments.

There are many other research studies now under way on anticalculus substances. For example, the recently reported clinical study by Jensen[47] utilizing dentifrices that contained dehydrated pancreas to reduce calculus formation is encouraging. The development of a satisfactory means of controlling calculus formation in the human seems imminent.

In progress is much research designed to evaluate the role of various types of stresses, occlusal and systemic, dietary deficiencies of all kinds, etc., on the causation and the prevention of periodontal disease. The findings in most instances are inconclusive. One can state in general that no exciting reports on the etiology of periodontal diseases have been made as yet.

Periodontal Therapy.—There have been rather dramatic advances in the field of periodontal therapy. Periodontists have gradually learned that surgical operation is indicated to a degree far more extensive than was believed desirable just a few years ago. It is now rather common practice among many periodontists to recontour alveolar bone, lower muscle attachments on the gingiva, and recontour gingival

tissues so that healing can occur promptly and to form the oral tissues to allow easy maintenance of oral hygiene and normal function.[48] Periodontists are performing many more minor tooth movements to restore normal relationships of teeth. Splinting is also receiving more attention in advanced cases of periodontal disease than previously.[49-53] For example, Curtis and Baum[49] described a technique for splinting teeth using multiple miniature pinholes. The alignment of all the pinholes in a parallel direction is done with a special aligning jig which is mounted onto the labial surface of the mandibular incisor teeth with impression compound. These authors report that the technique is not difficult or time-consuming and makes possible the retention of teeth the prognosis of which would be hopeless without splinting.

For stabilization of periodontally involved teeth when distal extension free-end denture bases are involved, Gottfriedsen[53] has suggested that the bases be rigid and united by a lingual bar attached to the abutments by a spring.

It is not easy to explain the wider acceptance of these rather dramatic treatments of advanced periodontal disease. Perhaps there is a combination of factors such as (1) the realization that, even though antibiotics are seldom used, they are available to control infections which might develop as a result of rather extensive oral surgical procedures; (2) willingness on the part of the periodontist to spend sufficient time on patients with advance periodontal disease, making it possible for these patients to retain their natural teeth in a healthy state; (3) advances in techniques of complete mouth reconstruction to restore occlusal function and distribute occlusal forces so that it is possible for teeth to remain in function even though much of the tooth attachment apparatus has been lost; and (4) an increase in the number of patients who value their natural teeth sufficiently to be willing to devote the time required to maintain oral cleanliness and the money to pay for extensive periodontal therapy.

These factors, and perhaps others, have resulted in advances in periodontal therapy which are quite dramatic.

Bruxism.—Bruxism is receiving renewed attention. This is due, in part, to newer research tools such as electromyography which permit a different approach to the problem. Sheppard[54] has discussed the symptoms and signs of bruxism, and certain of his recommended procedures follow the recommendation of D'Amico,[55] namely, that if the cuspid is steep enough and free in centric position, with approximately 0.5 mm. horizontal overlap, the patient cannot grind the teeth, and if they occlude solidly in centric position, he will soon lose the habit of bruxism.

Bruxism, as a factor in both tooth abrasion and periodontal breakdown, has been reviewed by Nadler.[56] He has considered all the factors (psychologic, occupational, and functional) which enter into the complex picture. Nadler states that it should be suspected in all cases of periodontal disease, and he has devised a lengthy questionnaire to analyze the factors which contribute to the condition. On the other hand, Ramfjord[57] claims complete success in the control of bruxism simply by occlusal adjustment.

Occlusion.—The literature in recent years has indicated an increasing interest in, and awareness of, the importance of occlusion. Development of better high speed

preparation methods and improved elastic impression materials has brought complete mouth treatment into the realm of general practice, calling for better understanding of problems of occlusion. Electromyographic studies indicate the importance of occlusal relationships to muscle activity and the possible conflicts which can lead to dental breakdown. The mechanical problems of producing physiologic occlusion have led to increasing interest in occlusion and treatment instruments.

Although the precise mechanisms are still obscure, there is an awareness that clinical evidence does point to some relationship between functional movements occurring in the temporomandibular joint and pathologic processes in the teeth and their supporting structures. Ramfjord and Moyers[58] have studied this electromyographically and previously reported that occlusion in centric relation is a fundamental requirement in the treatment of occlusion by equilibration, rehabilitation, or orthodontic therapy. Centric relation is a skull to mandible relation maintained by muscle action. Hjortso* points out that only in extreme positions of this joint, limited by the ligaments, is the joint held together by ligaments. In centric relation, the joint is held together by muscle activity. So it is important that centric occlusion be in a harmonious muscle relationship.

Sonesson,* as the result of tomographic studies, concludes "that the three axes of movement in the temporomandibular joint are clinically applicable and they give a basis for systematic registrations of the complicated movements in the temporomandibular joint."

Posselt* has, at the same time, analyzed the question of average locations of axes clinically as contrasted to the results from precise individual location. He concludes that in 33 per cent of the population, the use of average positions is clinically acceptable. But he points out that in practice there is no means for determining which patients fall into this category except by locating the axes and comparing these locations with average locations.

Occlusal Forms of Teeth.—Numerous studies have been conducted to investigate the relation of occlusal forms to acceptance by the patient and to chewing comfort and efficiency. Trapozzano concludes that there is no standard rule, but rather it is an individual problem. He suggests the advisability of making a chewing study of the patient prior to construction of restorations. No practical means to accomplish this has been presented. So many factors in addition to occlusal form enter into this complex area that it is not yet possible to draw a reliable conclusion.

Occlusion and Periodontics.—The periodontal implications of occlusion present the largest areas of inconclusive study. Whereas restorative dentists, in general, appear to believe that some such relationship does exist, periodontists are quite widely divided in their beliefs of the importance of this factor. In general, the opinion of many periodontists might be summarized in the statement that occlusion is a gross factor but not necessarily a precise relationship. Much has still to be learned in this most important area.

In reading and evaluating articles on occlusion, one must consider it in its physiologic relation to maintaining a state of health and not the mere mechanics of its relationships. In this respect, we face a situation analogous to the treatment

*E. Granger: Personal communication.

of any complex pathologic state. Many factors enter into it. When it is investigated from the aspect of any one of these, facts emerge which are a part, but *only* a part, of the whole picture. The relation of joints, muscles, tooth forms, bone metabolism, emotional states, psychosomatics, genetics, and other unknown factors all require consideration. When enough facts from these and other sources have been accumulated, it may be possible to assemble them in a broad synthesis of the entire problem. As in the case of dental caries, this synthesis has yet to be made. Lacking this information, treatment is dependent on those measures which, in the hands of the individual dentist, have been found to be clinically effective.

CONCLUSION

The year 1960 saw marked progress in the penetration of barriers, leading to an understanding of the mechanisms of dental caries, calculus formation, and the muscle-occlusion relationship. In particular, a trend noted in recent years to relate the mechanical and physical characteristics of materials, instrumentation, and treatment procedures to the entire oral environment continues to gain momentum. The completion of the report by the research committee of the Commission on the Survey of Dentistry in the United States has provided a valuable yardstick by which dentistry in the future may measure its progress and will be able to determine how well it has met the research responsibilities which it now faces.

I would like to thank the members of this committee for their cooperation in submitting certain material. Since an attempt was made to include the latest research and because time and distance prevented a committee meeting, this report had to be written and compiled by the chairman. Therefore, the other members of the committee should be held responsible only for the meritorious sections of the report but not for any of its faults.

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STABILITY OF MANDIBULAR REST POSITION

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MANDIBULAR REST POSITION is an important factor in the treatment plan for many patients. The interocclusal distance as based on this position often determines an orthodontic procedure or the prosthetic restoration that is constructed for the patient.

Past findings on the stability of mandibular rest position range from a constancy that exists throughout life[1] to an instability at the same sitting.[2] The purpose of this investigation was to test the stability of mandibular rest position by two methods.

Two groups of dentulous subjects with random occlusions were selected. Each group was made up of 11 dental students. In group I the mandible was determined to be at rest position by electromyography alone, while electromyography combined with clinical means was used for group II.

RECORDING PROCEDURES

The electrical activity from the middle fibers of the temporal and the anterior belly of the digastric muscles was used to determine electromyographic rest position. Surface electrodes were attached with adhesive tape to the skin overlying these muscles. A surface electrode attached to the forehead was used as the ground and one attached to the tip of the nose as the reference electrode. Since only the presence or absence of electrical activity is the criterion for the rest position, the five point generalized reference system was not used.[3]

The recording instrumentation consisted of a six channel polygraph† for pen recording, a cathode ray oscillograph‡ for visual monitoring, and a high fidelity amplifier and speaker§ for aural monitoring. The oscillograph and the high fidelity amplifier were connected to the output terminals of the amplifiers of the polygraph (Fig. 1). By this arrangement, the electrical activity from the temporal muscle was recorded simultaneously by the pen writer and the visual monitoring system and the activity from the digastric muscle by the pen writer and the aural monitoring system.

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†Grass model 5P3.

‡Du Mont type 401.

§Bell model 2315.

After electrode attachment, the subjects were positioned in a Margolis cephalometer (Fig. 2), and the headpost readings were recorded for subsequent sittings. Cephalometric roentgenograms were made with the mouth wide open and with the teeth in centric occlusion. These roentgenograms were made to permit accurate orientation of later tracings. No electromyograms were made during these exposures.

Two additional roentgenograms were made of each subject at this sitting with the mandible at rest position. For group I, the roentgenogram was made when the recording instruments registered the lowest voltages from the two muscles (Fig. 3). For group II, the rest position was determined both clinically and electromyographically. To obtain clinical rest position, the patient was instructed to say *m* and then swallow. This procedure was repeated several times. When visual observation showed that rest position coincided clinically and electromyographically, the roentgenogram was made.

Following a period of approximately 1 year, two more roentgenograms of rest position were made of each subject at one sitting (Fig. 4). Rest position was determined for each group in the same manner as at the first sitting. Thus, four roentgenograms of rest position were made for each subject, a total of forty-four for each group. The maximum radiation exposure for the entire procedure was 0.7 r.*

TRACINGS

Each roentgenogram was placed on a special drafting table with a built-in shadow box. An acetate tracing film was placed over the roentgenogram and fixed in place with tape. The anatomic structures identified on the roentgenograms and drawn on the paper were the (1) sella turcica, (2) nasion, (3) orbitale, (4) pterygomaxillary fissure, (5) porion, (6) maxillae (anterior nasal spine to posterior nasal spine), (7) lower central incisor and first molar, (8) upper central incisor and first molar, and (9) mandible (including condyloid and coronoid processes if visible).

MEASUREMENTS

Two linear and three angular measurements were made on each tracing (Fig. 5). The linear measurements were (1) from nasion to menton and (2) from the nasion to the incisal edge of the upper central incisor. The nasion-menton measurement *(NM)* was used to record the face height in millimeters at rest position. The nasion-incisor measurement was used as a control. The three angular measurements were (1) the angle formed by the lines from sella turcica to nasion to menton *(SNM)*, (2) the angle formed by the lines from nasion to sella turcica to menton *(NSM)*, and (3) the angle formed when the mandibular plane intersects the sella turcica–nasion plane. Angular measurements were made to the nearest ½ degree. Linear measurements were made to the nearest 0.5 mm.

The data were referred to the Statistics Aids Laboratory of the Ohio State University for analysis.

*S. Kolas: Personal communication.

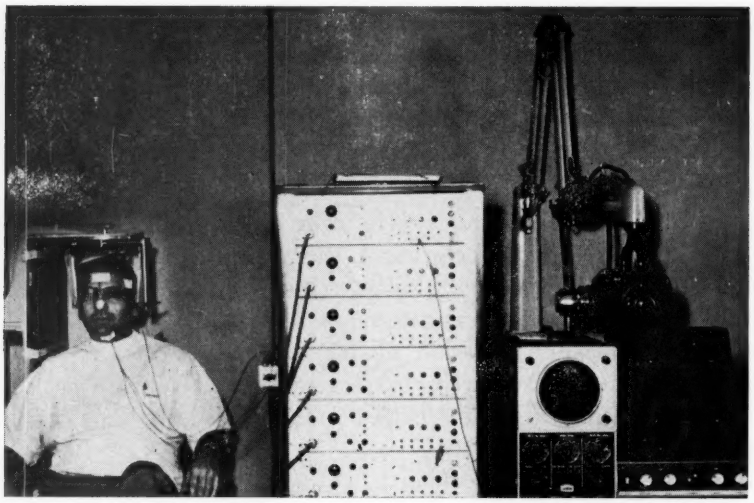

Fig. 1.—The electrical activity is recorded simultaneously by an ink-writing polygraph (middle), an oscillograph, and an aural monitoring system (extreme right).

MEASUREMENT OBSERVATIONS

The greatest single variation in the *NM* measurement between the two rest position roentgenograms made at the same sitting was 2.5 mm. However, the variation in this measurement in thirty-six of forty-four instances was within 1 mm.

The greatest variation in the *NM* measurement among the four rest position roentgenograms for a single subject was 3.5 mm. However, when the average of the two measurements of the first sitting was compared with the average of the two measurements 1 year later, sixteen of twenty-two were within 1 mm.

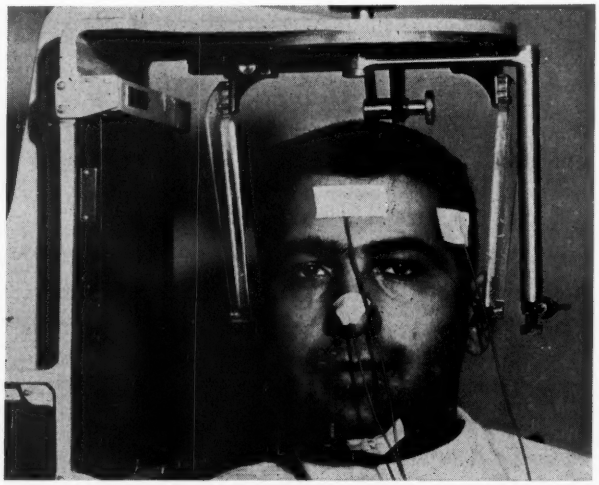

Fig. 2.—The subject is positioned in the Margolis cephalometer. Note the attachments of the surface electrodes.

Eight of 22 subjects showed a variance of more than 1 degree in both the *SN* plane–mandibular plane angle and the *NSM* angle. Only 4 subjects showed a variance of more than 1 degree in the *SNM* measurements. The greatest variation in the control measurement was 0.5 mm. This difference occurred in 6 subjects.

STATISTICAL ANALYSIS

The mean for each sitting and between sittings was determined for each group. The standard deviation for each sitting, between sittings, and for measurement error was computed. An analysis of variance (F) was done for each group and between the groups to test the significance of the differences with respect to the error. The F value obtained from an analysis of variance is compared to a known F value for similar situations. If the determined F value is less than the known F value, the differences are not considered significant. If the determined F value is greater than the known F value, the differences *are* considered significant. The standard deviations and F values for each sitting, between sittings, and between groups are seen in Table I.

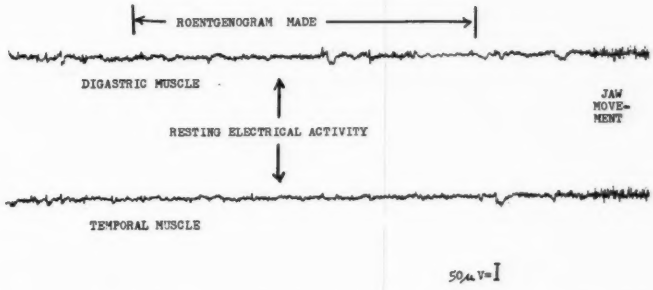

Fig. 3.—An electromyogram indicates the lowest voltages from the digastric and temporal muscles, at which level the roentgenogram was made.

Therefore, by comparing the determined F value with the known F value at the 10 per cent level, the statistical analysis indicated (1) the rest position was stable within the individual at the same sitting, (2) the rest position was stable within the individual at different sittings approximately 1 year apart, and (3) there was no significant difference between the methods tested. However, the lower error variance for group II (0.404 to 0.790) indicates that the electromyographic plus clinical method has a trend for more accuracy than the electromyographic method.

DISCUSSION

Whether statistical differences are of a magnitude to be significant depends upon the error in any given experiment. The error is that amount of the total variation that cannot be explained in any logical manner. If the error is small, small differences will be statistically significant, while if the error is large, larger differences may *not* be significant.

Fig. 4.—Records of rest position are made at the same sitting and at different sittings on cephalometric roentgenograms.

Therefore, although the differences in rest position in this experiment were not statistically significant, this significance was based entirely upon the error in the experiment. The standard deviation of the error in group I was 0.89 mm. and in group II 0.64 mm. Both of these errors are considered small. Nonetheless, this error means that 68 per cent of the individuals measured similarly to group I would be expected to have unaccountable differences in jaw position that would fall

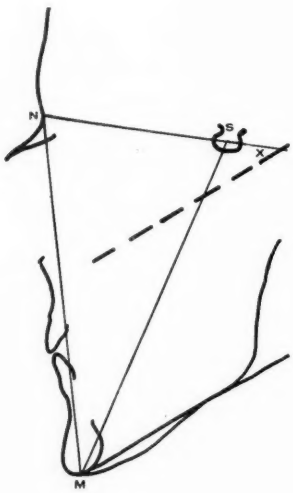

Fig. 5.—Tracings from the cephalometric roentgenograms are used to compare the position of the mandible during rest position at the various intervals.

TABLE I. MANDIBULAR REST POSITION COMPARED STATISTICALLY

GROUP	S.D. (MM.)	ANALYSIS OF VARIANCE (F)
I. Electromyographic method		
Same sitting	0.75	0.72
Between years	1.05	1.12
Error	0.89	
10% F		*3.29*
II. Electromyographic plus clinical method		
Same sitting	1.12	3.14
Between years	0.52	0.67
Error	0.64	
10% F		*3.29*
Comparison (error variance)		$\frac{0.790}{0.404} = 1.96$
10% F		*2.32*

within ± 0.89 mm.; for group II they would fall between ± 0.64 mm. Thus, with the rest position measurement systems available, including electromyography, differences of the magnitude of 1 to 1.5 mm. cannot necessarily be attributed to jaw movement, since these differences lie within the possible range of the measurement error.

The greatest single variation in rest position at the same sitting was 2.5 mm., and among four roentgenograms of the same patient over a 1 year period it was 3.5 mm. These differences are surely clinically significant and represent jaw movement for some reason.

Therefore, from our data, it is impossible to state that rest position is stable at all times for all individuals. Rather, the data indicate that the position is stable for most individuals under normal conditions but, for varying reasons, may be unstable for others. A better measurement system must be devised for data to indicate that small changes are solely a result of changes in mandibular rest position.

SUMMARY

The stability of mandibular rest position was tested by two methods. A statistical analysis of the data indicated that there was no significant difference in mandibular rest position at the same sitting, between sittings approximately 1 year apart, or between the two methods. However, differences were of a magnitude to make the stability of rest position questionable for certain individuals. Similar measurements from both groups after the third year will add information as to the reliability of the methods tested and to the constancy of the position.

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USE OF ULTRASONIC TECHNIQUES FOR CLEANING INSTRUMENTS AND APPLIANCES

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THE USE OF ULTRASONIC TECHNIQUES is becoming increasingly popular in industry and elsewhere for the removal of many types of surface contaminants and in various finishing processes. Ultrasonic cleaning has replaced conventional methods in many instances because of its greater effectiveness and efficiency. The necessity for effective cleaning procedures in the dental office and laboratory is well recognized. It was decided, therefore, to explore the potential use of ultrasonic means for the removal of contaminants peculiar to dental practices.

EQUIPMENT

The ultrasonic cleaning unit (Fig. 1) consists of a generator, a transducer, and a tank. The generator provides high frequency electrical energy which is converted by the transducer into mechanical energy in the form of high frequency sound waves. In the two units which were used, the transducer operates on the piezoelectric principle with barium titanate as the electrostrictive material. The transducer is located in the base of the tank. High frequency sound waves flow through a cleaning solution perpendicular to the face of the transducer. During the rarefaction half of the vibration cycle, vapor bubbles are formed in the cleaning solution. The rapid collapse of these vapor bubbles results in the phenomenon cavitation. A soiled object placed into this cavitating solution is bombarded by the action of these microscopic bubbles. As the bubbles collapse, energy is released which mechanically aids in the removal of the contaminant from the instrument or appliance surface. The basic cleaning ability of a solution is thus enhanced by this mechanical phenomenon. Generally, the lower range of ultrasonic frequencies is more effective because of the higher amplitude, which results in a greater number of vapor bubble bursts. The higher frequencies, while not as effective in producing the vapor bubble action, have the ability to penetrate narrow channels and blind recesses.

The ability of a solution to cavitate becomes equally important to its inherent cleaning properties since ultrasonic cleaning is accomplished by both the physical agitation and the chemical dissolution and/or dispersal of the dirt. Water cavitates most effectively between 140° F. and 160° F. because of its suitable vapor pressure.

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Introducing a detergent into the water lowers the surface tension and reduces the energy required to do a specific task. Stoddard solvent and trichlorethane are organic solvents which cavitate well at room temperature.

Baskets for use in the ultrasonic cleaning tanks are designed with solid bottoms. Baskets with perforated bottoms will damp vibration through the cleaning fluid and its effect will be minimal. Since this vibration does penetrate most solid materials, subcontainers such as Pyrex beakers that contain different solutions may be used within the main tank. The vibrations are thus carried through water in the tank, penetrate the beaker, and cavitate the solution within the subcontainer. A number of different cleaning operations can be accomplished successively without the necessity of a change in solution in the main tank.

Such equipment is available at moderate cost as industrial units or with some modifications for dental use. The operational design of all of these units is similar.

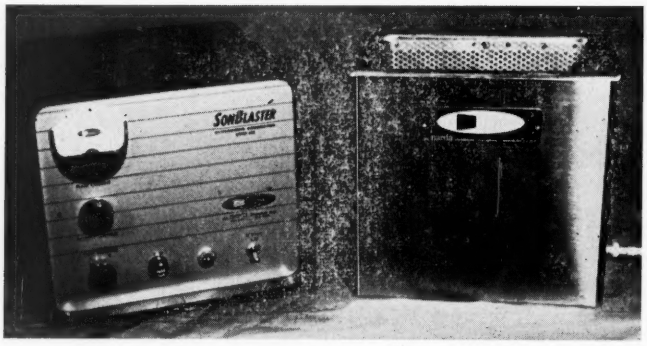


Fig. 1.—One of the ultrasonic cleaning units.

CLEANING INSTRUMENTS

In routine restorative and surgical procedures in dentistry, the common contaminants of most instruments are saliva and blood. Rotating, cutting, and grinding instruments have cut hard tooth tissue superimposed upon the saliva and blood. At times, all of these contaminants present some difficulty in removal, especially if they are allowed to dry upon the surface of the instruments.

Rotating diamond points, burs, hand instruments with serrated handles, and extraction forceps contaminated with various materials were allowed to air dry for varying periods up to 24 hours. Those instruments which had been allowed to dry from 30 minutes to 5 hours required from 1 to 3 minutes of ultrasonic agitation in a 2 per cent detergent solution for complete debris removal (Fig. 2). A large group of instruments on which the contamination had dried for 24 hours required a little more than 5 minutes agitation for complete cleaning. One advantage to this method of cleaning over some others is illustrated by the fact that the surface of the instrument itself is in no way adversely affected. The diamond particles, for example, did not appear to be dislodged even after prolonged continued agitation. Dried

mucus, blood, and other debris from the inner aspects of saliva ejectors are effectively removed in 3 to 5 minutes with this same detergent solution. Contaminated instruments subjected to ultrasonic cleaning at normal time intervals after usage are routinely cleaned in about 1 minute. These instruments subjected to ultrasonic cleaning are easily distinguished by their shiny appearance from those instruments which have been hand scrubbed.

CLEANING HANDPIECES

The lubricant within the bearing and geared areas of dental handpieces and contra-angles is present in addition to the normal oral contaminants. While one of the advantages claimed for the ultrasonic cleaning method is the ability to clean assembled mechanisms, it was necessary to partially disassemble these instruments so that the air might be displaced by the solvent to allow cavitation to occur in all of the soiled areas. This procedure also seemed to be necessary in order that the dislodged dirt would be allowed to fall free from these areas. The usual contamination of the contra-angle and straight handpieces is routinely removed in 1 or 2 minutes using Stoddard solvent as the working fluid. Severely contaminated contra-angles (those which were "frozen" and thus inoperable) have been freed of dirt, corrosion, and lubricant within a few minutes and again put into workable condition.

While trichlorethane cavitates very well and appears to clean instruments coated with lubricants, traces of hydrochloric acid are likely to be found in chlorinated hydrocarbons such as this which would be detrimental to the precision equipment.

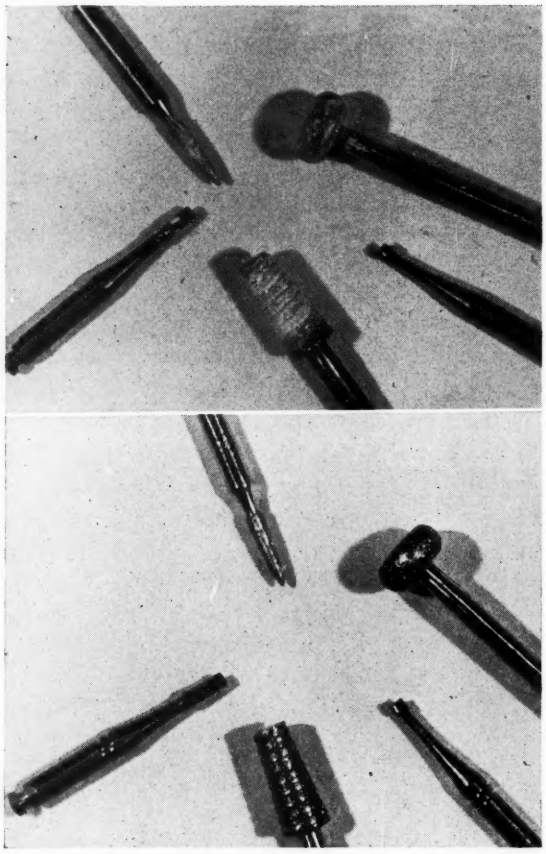
CEMENT REMOVAL

Silicate and zinc phosphate cements, because of their acid nature when mixed, are easily removed from instruments with sodium bicarbonate solution before setting occurs. After hardening, however, these cements may become very tenacious. An acid cleaner attacks the set cements, and this action is decidedly enhanced when subjected to ultrasonic vibration. A 2 per cent phosphoric acid solution in a nonionic detergent was found to be very effective for cement removal. Likewise, solutions of Sparex No. 2 or Jel-Pac,* which are cleaning and pickling agents for nonferrous metals, were used with good results.

The zinc oxide–eugenol cements present a more perplexing problem. Ammonia solutions are sometimes effective cleaners when the amounts of material are small, but not in larger volumes. Zinc oxide–eugenol pastes are nicely removed by use of Stoddard solvent or trichlorethane as the working vehicle under ultrasonic agitation. This process takes a little longer, since the surfaces exposed to the cavitating fluid are softened quickly, but the material does not readily fall away. While some of this material separates, the viscous mass at the surface tends to cohere and maintain its integrity, thus protecting to some degree the underlying material. This also occurs with some other materials when in large amounts.

*J. F. Jelenko & Co., Inc., New York, N. Y.

A.



B.

Fig. 2.—Rotating instruments cleaned by ultrasonic techniques. *A*, Before cleaning. *B*, After cleaning in a 2 per cent detergent solution.

CLEANING APPLIANCES

The common practice of pickling gold castings in an acid solution to remove the surface oxides fails, in most cases, to remove the residual investment particles. This necessitates the additional hand brushing of each casting in the attempt to clean them. With the use of ultrasonic techniques, large numbers of castings can be scrupulously cleaned in less than 2 minutes at room temperature using Sparex No. 2, Jel-Pac, or diluted hydrochloric acid (Fig. 3). Chrome-cobalt castings are very difficult to clean in contrast to the easily cleaned gold castings. This difficulty is the result of the action of the high temperature of the molten metal upon gypsum-bound and other investments. The use of ultrasonic means for cleaning of chrome-cobalt castings appears impractical when procedures similar to those used for gold castings are employed.

Attempts to remove plaster and stone from processed acrylic resin dentures by ultrasonic techniques are unsatisfactory. If adequate removal of these gypsum materials is attained, it occurs only after a prolonged period of time. Sodium citrate, which has been employed in a soaking procedure for the removal of plaster, was found to have too great viscosity for good cavitation. Variations of this solution and others, including a commercial preparation designed specifically for this task, were tried in conjunction with ultrasonic agitation, each with poor results. While the outer surface of gypsum softens rather readily, this material clings to the remaining mass and retards or prevents further removal of the gypsum.

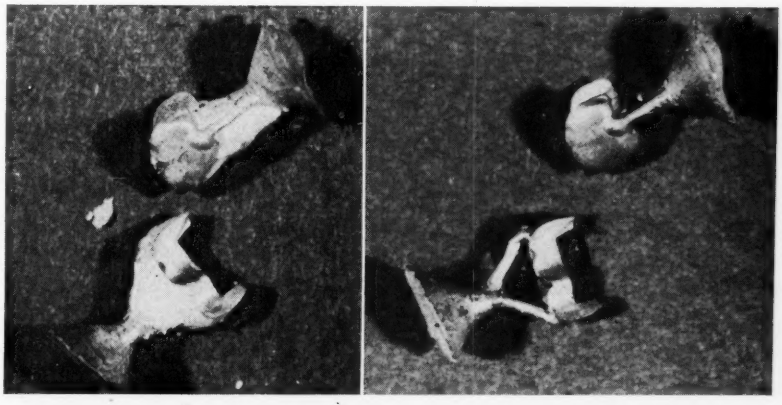
Wax and compound contaminants are readily removed from instrument surfaces, appliances, and equipment with the use of Stoddard solvent or trichlorethane as the working fluid in the tank. Where organic material is burned, leaving a carbonaceous deposit, the solvent-emulsion cleaners are effective.

Polishing materials such as Tripoli, Radoff, and rouge are cleansed from appliance surfaces in warm detergent solutions. Within a few minutes, complete cleanness may be attained on a large number of dentures.

CONCLUSIONS

Observations of two ultrasonic cleaning units, one operating at 90 kc., the other at 40 kc., show that the lower frequency unit is more suitable for dental purposes. Many cleaning tasks in the dental office and laboratory are accomplished with excellence when ultrasonic means are employed. Other tasks are best done by conventional means.

In order to define the value of ultrasonic cleaning for a particular dental installation, three questions should be considered: (1) Is a high degree of cleanness mandatory? (2) Is the cleaning task complicated by the design of the parts to be cleaned? (3) Do the cleaning operations require the expenditure of much time



A. *B.*

Fig. 3.—Refractory investment is removed from gold castings by ultrasonic means. *A*, Before cleaning. *B*, After cleaning in a pickling solution for 2 minutes.

by office and laboratory personnel? Almost any dental practice provides an affirmative answer to the first two questions. Ultrasonic techniques will assure routinely a high degree of cleanness. The number of items or the work load involved would seem to be the deciding factor. While there are definite limitations of its usefulness, many routine tasks may justify the use of the ultrasonic cleaning method.

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MISCELLANEOUS

PREPARATION OF TECHNICAL PAPERS

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The suggestions discussed in this article are designed to point out some aspects of the preparation required of a speaker. It should be obvious to the reader that considerable detail regarding philosophies, techniques, etc., has been omitted. Individuals who have given numerous presentations will no doubt find many of the suggestions helpful reminders. Inexperienced individuals should seek the assistance of a well-qualified person to aid in the preparation for a speaking engagement. Assistance offered will often shorten the time required to prepare for the appearance as well as provide a basis for maintaining the desired quality of the presentation itself.

For the purpose of this article, the following topics have been included: (1) planning for the presentation, (2) visual aids, (3) the audience, (4) the speaker, and (5) the meeting place.

PLANNING FOR THE PRESENTATION

Style and Approach.—There is a difference in the style and approach used to prepare material for oral presentation as in contrast to material for publication in a technical or scientific journal. Generally, the writer will follow the usual customs for the preparation of material for publication. However, an attempt to use in an oral presentation material prepared for publication generally results in a decrease in effectiveness and quality of delivery. Once this basic concept is understood by those who give oral presentations, their degree of success will improve.

Material prepared for oral presentation should be designed so that the speaker can use his material with ease and flexibility. The material should never be written with the idea of reading it to the audience. Some may choose to read their manuscripts rather than attempt to present the information in a less formal manner. In those cases in which the material is to be read, the speaker should design his final copy utilizing the phrase or central thought division concept. This technique is one in which the writer directs the typist to separate each group of words in phrase

*President.

form. When the material is read in this manner by the speaker, the audience hears a more casual presentation.

This technique . . . also eliminates many of the reading hazards . . . such as . . . improper grouping of words, . . . regressions or rereading words, . . . improper or misplaced emphasis, . . . and so on. The preceding sentence illustrates this design. Try reading the foregoing sentence aloud, taking a short breath or making a vocal pause for each three dots. With practice, one soon learns that following this technique improves the flow of the presentation.

Presentation Manuscript Versus the Backside of an Envelope.—The over-all quality of a presentation is directly proportionate to the time and effort spent in preparation. One of the first indications of lack of thorough preparation is discontinuity of the material being presented. Even the most experienced speakers will fall victim to such hazards as omitting points, side road comments, and loss of emphasis during a lecture. Supporting points are often omitted because the speaker momentarily fails to remember them. When the material has been well planned and outlined, valuable supporting details are never forgotten.

The Planning Step.—The more important aspects of planning for oral presentations are discussed here. Accordingly, the following points will be of value to both experienced and inexperienced speakers.

Objective: Before any written preparation can begin, the speaker must learn what is expected from him. Some invitations merely request the speaker to appear at a scheduled time and place. Often, the group extending an invitation gives the speaker a broad topic for which he may choose his own approach. This immediately places a speaker in a difficult situation, because he may not know the real desires or needs of the audience. Therefore, the speaker should communicate with those responsible for program planning to pinpoint the objective of the presentation. Once this is known, the speaker can begin preparations. When the objective has been determined, start with an outline of the presentation. Review and reorganize the outline to ensure continuity.

Outline: This should include all major points and supporting points coupled with ideas concerning potential visual aids. The first point in the outline should be a statement of purpose. This statement should include the objective of the presentation and an overview of the various major points in the lecture. This can be called a listener aid because it helps the listener to see clearly what will be presented. Some speakers prefer to use a visual aid (a slide or chart) to help convey the purpose of the lecture.

When the outline is being prepared, follow these tips: (1) study the selected approach to the subject; (2) think about the development of the subject in relation to the audience; (3) study the use of visual aids *after* a rough draft has been completed; (4) review lead-ins, transitions, and summaries; (5) check for accuracy of content; (6) anticipate the difficulty of subject matter in relation to the listener's ability to grasp the information presented.

Topics: As a general rule, between three and six topics seem to suffice so that the audience will not forget the purpose of the speaker's message. If a lecture contains too many points, there is a hazard that the audience may not retain all

of the information presented. Audience interest may lag and the value of many points is minimized if an excessive number of topics are presented.

Time: Some speakers feel that if 1 hour has been allotted to them for the presentation, 1 hour must be used. Strict adherence to a program time table may kill the impact of an otherwise good presentation. When planning the lecture, try to remain under the allotted time limit. Wherever possible, reduce the time required based upon the time needed to adequately present each point. In other words, use the time prudently but avoid filling the schedule with superfluous information.

Continuity: After a rough draft has been prepared, review the material, checking it for continuity and over-all fluency. Revise it as needed. A third person is often very helpful as a listener to help check the material for continuity.

Review: Depending upon the nature of the subject, the speaker should review his message, checking it for application and usefulness to the listener. Likewise, when the speaker plans to demonstrate a theory or technique, he should review his demonstration approach carefully so that each step in the process is clear from a listener's point of view.

Questioning: Questioning members of the audience creates considerable listener interest. Where this is practical, the speaker should develop questions concerning certain aspects of his lecture. These questions will do several things. Response from audience members tends to enhance interest, change the pace, and tell the speaker something about the extent of knowledge of the listeners and makes a general question and answer session after the formal presentation more productive.

Questioning is an art. The speaker must exercise good judgment in his choice of questions and give considerable thought to his method of approach in questioning members of the audience. In conclusion, questions should be relevant, clear, brief, definite, adapted to the audience level, directed to an individual, and limited to important concepts, principles, or facts.

Techniques: Lead-ins, transitions, and summaries add to the quality of the presentation. The purpose of a lead-in is to introduce a topic. This is nothing more than a one or two sentence statement designed to tell the audience that the speaker is starting a discussion on a new topic. A transition in the body of the lecture provides the bridge between a preceding summary and the lead-in for the next topic. Frequent summaries aid the listener to pigeonhole each major point of importance. When all three of these presentation devices are utilized, the lecture takes on an air of quality.

VISUAL AIDS

Lectures can be delivered with success without visual aids. However, a well-chosen visual aid adds value to the speaker's oral presentation when the aid fulfills certain requirements. These requirements are simple, yet important: (1) the visual aid must be clear, concise, and of simple design; (2) it must not be used as a crutch but *as an aid;* (3) it must help the speaker illustrate his point or focus attention on important implications that could not be explained easily without use of a visual aid.

Utilization of too many lantern slides or charts detracts from the speaker's ability to convey his message. A close review of the aid, checking for value and appropriateness, is necessary. Uniformity of visual aids is desirable in most cases. Visual aids should be selected after the basic material has been finalized. A speaker *should not* build his story around visual aids; rather, he should select aids which tend to support his commentary.

Before the scheduled presentation, the speaker should have several practice runs. One or two practice sessions are desirable to double check the continuity of the lecture so that its objective is satisfied. Additional practice sessions should be scheduled to check timing, familiarity with visual aids, and the technique of oral presentation.

THE AUDIENCE

The speaker will become acquainted, to a limited extent, with his audience in the process of establishing the objective of his lecture. At the time of presentation, the speaker should make an effort to become personally acquainted with as many members of the audience as possible before his scheduled appearance at the podium. Meeting audience members will help the speaker adapt his material to individual cases of interest to each listener. This process of meeting members of the audience aids in developing personal interest and rapport.

THE SPEAKER

The following items are of particular importance and deserve considerable attention:

Conversational Speech.—There should be evident a sense of communication—a conversational speaking quality.

Fluency.—Speak fluently, without awkward pauses and unnatural phrasing.

Diction.—Pronunciation, articulation, grammar, and word choice should be correct within reasonable limits.

Emphasis.—Make effective use of vocal inflection; avoid the recurrent, rhythmic pitch pattern and the monotone.

Volume.—Speak loudly enough for all to hear.

Vocalized Pause.—Keep the vocalized pause *(ah, er, uh,* "and-*uh*'s") under control.

Physical Activity and Energy.—The speaker's posture and bodily action should help his presentation; he should avoid harmful and distracting physical mannerisms; he should be physically alert and energetic.

Poise.—The speaker should be poised and free from the influence of self-consciousness and stage fright.

Timing or Pace.—Practice will improve the timing. A change of pace tends to strengthen the delivery.

Showmanship.—The speaker should practice techniques of oral presentation that work well for him. Personal characteristics integrated with the presentation manifest showmanship and salesmanship.

THE MEETING PLACE

As a rule of thumb, a speaker should make it a point to arrive at the designated meeting place well in advance of his scheduled appearance. Upon arrival, he should review the arrangement of equipment he will use to see that all is in good working order. If changes in seating arrangement are desirable, time should be allowed for rearrangements. Ventilation and lighting, although beyond the speaker's realm of responsibility, should likewise be checked. If problems exist with either item, steps should be taken to correct them. Both elements compete with the speaker for audience attention.

SUMMARY

The comments set forth in this article are admittedly brief. Those individuals interested in exploring various aspects of the art of communication will find many excellent books covering various subjects in this field readily available for study. Pursuit of additional knowledge is both rewarding and enjoyable. As one improves his ability in the field of oral presentation, he will find his speaking appointment book being marked with an increasing number of engagements.

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THE AMERICAN BOARD OF PROSTHODONTICS

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Detroit, Mich.

THE 1960 EXAMINATION by the American Board of Prosthodontics was held at Georgetown University, School of Dentistry, Washington, D. C., July 25 through 30.

The following candidates met the Board requirements and have been certified to practice the specialty of prosthodontics: Dr. A. H. Bassman, Milwaukee, Wis.; Dr. Robert J. Crum, Hines, Ill.; Major Glen S. Gamble, El Paso, Texas; Dr. Robert E. Herlands, Stamford, Conn.; Dr. Judson C. Hickey, Columbus, Ohio; Major David R. Jordan, APO New York, N. Y.; Dr. J. L. Long, Jr., Daytona Beach, Fla.; Dr. M. Mazaheri, Lancaster, Pa.; Dr. Donald D. Myers, San Bernadino, Calif.; Dr. F. A. Pflughoeft, Wauwatosa, Wis.; Dr. John B. Sowter, Chapel Hill, N. C.; Major Virgil Woods, Phoenixville, Pa.

Dr. Daniel H. Gehl of Milwaukee, having served the Board faithfully for 6 years, retired as a Board member at this meeting. Dr. Lynn S. Dirksen, Professor of Prosthodontics at Emory University, School of Dentistry, Atlanta, was elected as a new member of the Board.

The 1961 examination will be held at Northwestern University, School of Dentistry, Chicago, Aug. 14 through 19.

Information and applications for the 1962 examination may be secured from the Secretary, Dr. Charles H. Jamieson, 563 David Whitney Bldg., Detroit 26, Mich.

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Bert L. Hooper	1009 Sharp Bldg., Lincoln 8

Nevada

John E. Craddock	820 S. Seventh St., Las Vegas

New Jersey

L. Thomas Asche	37 James St., Newark 2
Martin J. Cain, Jr.	Hamilton Bldg., 43 W. Front St., Red Bank
James V. Giordano	425 Union Ave., Paterson 2
Charles M. Moore	205 Park St., Montclair
Leonard R. Moore	944 Stuyvesant Ave., Union

New York

I. Kenneth Adisman	100 Central Park, S., New York 19
Louis Blatterfein	1 Hanson Pl., Brooklyn 17
Sebastian A. Bruno	23-33 30th Ave., Astoria 2
Max P. Fishberg	Fajen Bldg., Main St., New City
Joel Friedman	499 Lincoln Pl., Brooklyn 38
Samuel Friedman	146 E. 49th St., New York 17
George W. Hindels	815 Fifth Ave., New York 21
William C. Hudson, Jr.	630 Fifth Ave., New York 20
Ira E. Klein	730 Fifth Ave., New York 19
Joseph S. Landa	136 E. 54th St., New York 22
Harold J. Levine	123 W. 57th St., New York 19
John J. Lucca	630 W. 168th St., New York 32
Richard C. Mast	123 E. 37th St., New York 16
Edward J. Mehringer	260 Smallwood Dr., Buffalo 26
Raymond J. Nagle	New York University, School of Dentistry, 209 E. 23rd St., New York 10
Harold R. Ortman	3800 Main St., Eggertsville 26
S. Howard Payne	University of Buffalo, School of Dentistry Campus, Buffalo 14
Max A. Pleasure	21-36 33rd Rd., Long Island City 6
Clyde H. Schuyler	400 Madison Ave., New York 17
Thomas E. J. Shanahan	861 Carroll St., Brooklyn 15
Sidney I. Silverman	80 Park Ave., New York 16
Gilbert P. Smith	430 W. 116th St., New York

North Carolina

Lucian G. Coble	907 Cornwallis Dr., Greensboro
David P. Dobson	University of North Carolina, School of Dentistry, Chapel Hill
Monte G. Miska	University of North Carolina, School of Dentistry, Chapel Hill
John B. Sowter	University of North Carolina, School of Dentistry, Chapel Hill

Ohio

Theodore A. Bodine	1207 Akron Savings & Loan Bldg., Akron 8
Carl O. Boucher	314 Beggs Bldg., 21 E. State St., Columbus 15
James D. Chessrown	905 Mahoning Bank Bldg., Youngstown 3
Samuel S. Cohen	Park-Chester Medical Bldg., 10605 Chester Ave., Cleveland 6
Judson C. Hickey	Ohio State University, College of Dentistry, Columbus 10
Walter J. Pryor	1026 Rose Bldg., Cleveland 15
John I. Sloan	1032 Rose Bldg., Cleveland 15

Oklahoma

Gustav A. Roelke	1112 Medical & Dental Arts Bldg., Tulsa 3

Oregon

Saul C. Robinson	401 Professional Bldg., 1033 S.W. Yamhill St., Portland 5

Pennsylvania

Victor E. Beresin	Spruce Street Medical Bldg., 269 S. Nineteenth St., Philadelphia 3
Muller M. DeVan	Spruce Street Medical Bldg., 269 S. Nineteenth St., Philadelphia 3
Charles P. Egoville	4005 Chestnut St., Philadelphia 4
M. Mazaheri	Lancaster Cleft Palate Clinic, 24-26 Lime St., Lancaster
Robert L. Pearce	Veterans Administration Hospital, Leech Farm Rd., Pittsburgh 6
Edmund A. Travaglini	107 Rolling Rd., Carroll Park, Philadelphia 51
Russell W. Tench	4126 Wilshire Dr., York
Walter F. Wade	805 Myrtle St., Erie

Tennessee

James R. Douglas	383 Meadowcrest Circle, Memphis 17
Elmer E. Francis	704 Hickman Bldg., Memphis 3
Robert T. Holt	Kennedy Veterans Administration Hospital, Memphis
Herman C. Levitch	University of Tennessee, College of Dentistry, 847 Monroe Ave., Memphis
W. D. Pearson	938 McCallie Ave., Chattanooga 3

Texas

Heinz Otto Beck	University of Texas, P. O. Box 20068, Houston 25
Eugene L. Brown	623 S. Henderson, Fort Worth
Emet P. Dickson	603 First National Bank Bldg., Paris
Frederick C. Elliott	The Texas Medical Center, 1133 M.D. Anderson Blvd., Houston 25
George B. Foote	Baylor University, College of Dentistry, Dallas 10
Edgar T. Gillean	1219 Medical Arts Bldg., Dallas 1
Thomas H. Kennedy	35 Highland Park Shopping Village, Dallas 5
Frederick R. Krug	2530 Savannah Ave., El Paso
John D. Larkin	791 Edgewater, New Braunfels
Lewis C. Turner	845-847 Milam Bldg., San Antonio 5

Virginia

Stuart J. Horner	7 Bowles La., Glen Allen
Alexander L. Martone	Medical Tower, Suite 909, Norfolk Medical Center, Norfolk 7
Douglas C. Wendt	3108 Tenth Rd., N., Arlington

Washington

Charles S. Ballard	1129 Medical Dental Bldg., Seattle 1
Bernard Jankelson	652 Stimson Bldg., Seattle 1
Arne G. Lauritzen	1314 Lakeside Ave., S., Seattle 44

West Virginia

Edward J. deKoning	Professional Bldg., 1300 Market St., Wheeling
Jed C. Wilcoxen	708 Second St., St. Marys

Wisconsin

A. H. Bassman	411 E. Mason St., Milwaukee
Ralph A. Bêhnke	5726 W. National Ave., West Allis
Lawrence W. Gabert	14235 W. Wisconsin Ave., Elmgrove
Daniel H. Gehl	735 N. Water St., Milwaukee 2
Joseph E. Hoffman	606 W. Wisconsin Ave., Milwaukee 3
F. A. Pflughoeft	7023 Grand Parkway, Wauwatosa

Puerto Rico

Arthur H. Schmidt	University of Puerto Rico, School of Dentistry, San Juan 22
Roy L. Bodine	University of Puerto Rico, School of Dentistry, San Juan 22

DIPLOMATES IN THE ARMED SERVICES 1961*

Leslie R. Allen, Lt. Col., USAF (DC)	19615 A-USAF Hospital, Box 95, Tachikawa, APO 323, San Francisco, Calif.
William P. Barnes, Jr., Lt. Col., DC, USA	Box 306, Tusah, APO 438, San Francisco, Calif.
Perry W. Bascom, Lt. Col., DC, USA	Dental Det., USA Garrison, Fort Riley, Kan.
John F. Bowman, Capt. (DC) USN	Narbrook Pk., Narberth, Pa.
Allen A. Brewer, Col., USAF (DC)	S.A.M. 2317, Brooks Air Force Base, Texas
Milton H. Brown, Capt. (DC) USN	P.O. Box #64—Navy #115, FPO, New York, N. Y.
Sebastian J. Campagna, Major, DC, USA	Chief, Prosthetic Section, Dental Clinic, SETAF, 45th Field Hospital, APO 221, New York, N. Y.
Judge C. Chapman, Capt. (DC) USN	Dental Clinic, US Naval Air Station, Pensacola, Fla.
John P. Christensen, Col., DC, USN	25 General Plaza, Fort Dix, N. J.
Henry A. Collett, Capt. (DC) USN	555 S.W. First St., Miami 36 Fla.
Walter W. Dann, Capt. (DC) USN	US Naval Dental Clinic, Navy No. 128, FPO, San Francisco, Calif.
Walter J. Demer, Capt. (DC) USN	5804 Ogden Ct., Washington 16, D. C.
Louis Emory, Lt. Col., DC, USA	2nd Field Hospital, APO 407, New York, N. Y.
Pierre O. Evans, Col., DC, USA	Box 6306, Fitzsimons Army Hospital, Denver 30, Colo.
James M. Fairchild, Col., DC, USA	US Army Dispensary, Room 2D-201, The Pentagon, Washington 25, D. C.
William M. Fowler, Capt. (DC) USN	Dental Det., Marine Corps Recruit Depot, Parris Island, S. C.
Arthur R. Frechette, Capt. (DC) USN	US Naval Dental School, National Naval Medical Center, Bethesda 14, Md.
John R. Frost, Lt. Col., DC, USA	538 Wheaton Rd., Fort Sam Houston, Texas
Glen S. Gamble, Maj., DC, USA	William Beaumont General Hospital, El Paso, Texas
Oren H. Gaver, Capt. (DC) USN	Camp Dental Dept., Marine Corps Base, Camp Lejeune, N. C.
W. Irwin Gullett, Capt. (DC) USN	250 Tamarack Ave., Carlsbad, Calif.
Charles M. Heartwell, Capt. (DC) USN	5440 Argall Crescent, Norfolk, Va.
Charles D. Hemphill, Capt. (DC) USN	1467 Jefferson St., San Francisco 23, Calif.
Davis Henderson, Capt. (DC) USN	Dental Dept., Naval Air Station, Jacksonville 10, Fla.
Frank E. Jeffreys, Capt. (DC) USN	Dental Dept., Naval Station, Long Beach, Calif.
Frank C. Jerbi, Col., DC, USA	307 Austin Loop, Fort Benning, Ga.
David R. Jordan, Maj., USAF (DC)	3970 USAF Hospital (SAC), Box 4075, APO 283, New York, N. Y.
Stephen T. Kasper, Capt. (DC) USN	District Dental Office, IND, Navy Bldg., 495 Summer St., Boston 10, Mass.
Ellsworth K. Kelly, Col., DC, USA	Box 307, Walter Reed Army Hospital, Washington 12, D. C.
Frank J. Kratochvil, Jr., Comdr. (DC) USN	4023 Wexford Dr., Kensington, Md.
Frank M. Kyes, Capt. (DC) USN	District Dental Officer, Hq., 9th Naval Dist., Great Lakes, Ill.
James B. Lepley, Capt. (DC) USN	US Naval Hospital Dental Service, San Diego 34, Calif.
Donald O. Lundquist, Maj., DC, USA	Madigan Army Hospital, Tacoma 99 Wash.
Robert B. Lytle, Capt. (DC) USN	MOQ 2301, Camp Lejeune, N. C.
William M. Marking, Capt. (DC) USN	4995 Cuba Millington Rd., Millington, Tenn.
Allen L. McInturff, Capt. (DC) USN	National Naval Medical Center, Bethesda, Md.
Charles W. Miller, Capt. (DC) USN	Apt. 3A, 8835 162nd St., Jamaica 32, N. Y.
Gordon L. Miller, Capt. (DC) USN	262 Sereno Dr., Vallejo, Calif.
Paul A. Miller, Col., DC, USA	196th Station Hospital, APO 163, New York, N. Y.
James B. Neil, Col., DC, USA	90th Medical Det., APO 154, New York, N. Y.
V. J. Niiranen, Capt. (DC) USN	Force Dental Officer, Hq., FMF Pacific, FPO, San Francisco, Calif.

*All of these addresses are subject to change.

Benjamin W. Oesterling, Capt. (DC) USN	4531 Cover St., Riverside, Calif.
Edmund S. Olsen, Jr., Col., DC, USA	Central Dental Laboratory, Walter Reed Army Medical Center, Washington 12, D. C.
Raymond H. Osterholtz, Major, DC, USA	1123 Duane Ave., Rolla, Mo.
Mack L. Parker, Capt. (DC) USN	Bureau of Medicine & Surgery, Navy Dept., Washington 25, D. C.
Kenneth D. Rudd, Lt. Col., USAF (DC)	742 Clearview Dr., San Antonio, Texas
Jack H. Sault, Capt. (DC) USN	511 Byron St., Palo Alto, Calif.
Clare W. Sauser, Lt. Col., DC, USA	180 N. Ridge St., Southern Pines, N. C.
Julius C. Sexson, Col., DC, USA	024630, Dental Det., Fort Ord, Calif.
Edwin H. Smith, Jr., Col., DC, USA	89 MD (Dental Det.), APO 403, New York, N. Y.
John B. Stoll, Capt. (DC) USN	Naval Dental School, National Naval Medical Center, Bethesda 14, Md.
Harold R. Superko, Capt. (DC) USN	US Naval Hospital, Oakland, Calif.
Christopher E. Thomlinson, Capt. (DC) USN	11th Force Dental Company (Aviation), Marine Wing Hq. Group, 1st Marine Aircraft Wing, Aircraft, FMF Pacific, FPO, San Francisco, Calif.
Herbert J. Towle, Jr., Capt. (DC) USN	7917 Sleaford Pl., Bethesda 14, Md.
Myron G. Turner, Capt. (DC) USN	US Naval Dental School, National Navy Medical Center, Bethesda 14, Md.
Robert L. Walsh, Col., DC, USA	Sixth US Army Central Dental Lab., 2155 Webster St., Alameda, Calif.
Robert H. White, Lt. Col., DC, USA	ASR 0-1702671, Dental Det. (4005-04), Fort Hood, Texas
Virgil Woods, Maj., DC, USA	Box 237, Valley Forge General Hospital, Pheonixville, Pa.

READERS' ROUND TABLE

NEW YORK, N. Y.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

We have read with considerable surprise the article in your November-December issue (10:1055, 1960) by Silver, Klein, and Howard on porcelain baked to metal. Their published physical properties of Improved Ceramco do not correspond with our published properties, although they do compare somewhat with a Ceramco gold alloy made over a year ago before the alloy was changed to Improved Ceramco #1. Unfortunately, the properties which they published focus an unfavorable light on the present Ceramco technique.

Our tests show that the physical properties of Ceramco #1 are as follows:

Yield strength	33,000
Ultimate tensile strength	51,000
Brinell hardness No.	150

The Brinell hardness of 150, which Silver, Klein, and Howard attempt to dispute, has been confirmed by tests made by the Dental Materials Department of Indiana University under the supervision of Prof. Ralph W. Phillips.

At a time when the porcelain baked to gold technique has attracted so much interest, it is unfortunate that an article on this subject could not have been more objective.

Very sincerely yours,

JOHN S. SHELL
TECHNICAL DIRECTOR OF RESEARCH
J. F. JELENKO & CO., INC.
NEW YORK, N. Y.

WASHINGTON, D. C.

EDITOR, THE JOURNAL OF PROSTHETIC DENTISTRY:

In the January-February issue of THE JOURNAL OF PROSTHETIC DENTISTRY (11:16, 1961), Drs. George A. Hughes and Carl P. Regli presented an excellent article entitled "What Is Centric Relation?" I wish to call to your attention an omission and something which could result in a misunderstanding of the effectiveness of my philosophy on attaining centric relation (centric maxillomandibular relation).

The authors said, "Some prosthodontists believe that . . . centric relation should be recorded with zero pressure. Others recommended that light pressure be used. Silverman insists that heavy stress be exerted while registering centric relation. The proponents of the nonpressure technique invariably incorporate remounting and equilibrating the occlusion after dentures are constructed to compensate for resiliency of tissue under masticating pressure. The proponents of the functional or pressure techniques expect to do little or no correction of the occlusion after delivery of the dentures."

I wish to call to the attention of the readers that I do correct the occlusion of dentures after delivery to the patient, and this is done in each and every case. This was reported in my article to which the authors referred, "Centric Occlusion and Jaw Relations and Fallacies of Current Concepts," which appeared in the November-December, 1957, issue of THE JOURNAL OF PROSTHETIC DENTISTRY. Please note that in my article (pp. 754 and 767) I do advise "to remount the intraoral central bearing device on the completed dentures to check for deflective occlusal contacts." Also, under "Conclusions," item 8 reads, "An intraoral central bearing device with its resultant biting point should be used on all complete dentures after their insertion and initial settling to equilibrate the centric occlusion."

If the principles and technique of using the resultant biting point as described in my article are added to the complete denture techniques of the readers, it would soon be learned that all patients can be normal and that there is no problem whatsoever in obtaining the horizontal relationship of centric relation.

Sincerely yours,

MEYER M. SILVERMAN, D.D.S.

NEWS AND NOTES

MEETINGS

Southeastern Academy of Prosthodontics, Americana Hotel, Miami Beach, Fla., May 18 to 21, 1961.

2nd National and 1st International Competition of Dental Prosthesis, "La Spatola d'Oro" (The Golden Spatula), Torino, Italy, June 3 to 6, 1961.

Twelfth Annual Berkshire Conference in Periodontology and Oral Pathology, Eastover Hotel, Lenox, Mass., June 18 to 22, 1961.

Bicentennial of the Death of Pierre Fauchard, Paris, July 1 and 2, 1961. For further information write to M. Max Filderman, Secrétaire Général du Comité National du Bicentenaire de Fauchard, 67, rue de Tocqueville, Paris XVIIe, France.

Fédération Dentaire Internationale, 49th Annual Session, Helsinki, Finland, July 9 to 15, 1961. For further information write to Mr. G. H. Leatherman, 35 Devonshire Pl., London, W.1, England.

Australian Dental Association, 16th Australian Dental Congress, Sydney, New South Wales, Aug. 14 to 18, 1961.

Pacific Coast Society of Prosthodontists, Empress Hotel, Victoria. B. C., Aug. 31 to Sept. 2, 1961.

American Academy of Maxillofacial Prosthetics, Benjamin Franklin Hotel, Philadelphia, Pa., Oct. 11 to 13, 1961.

American Denture Society, Drake Hotel, Philadelphia, Pa., Oct. 13 and 14, 1961.

American Society of Dentistry for Children, 34th Annual Meeting, Bellevue-Stratford Hotel, Philadelphia, Pa., Oct. 13 to 15, 1961.

Greater New York Academy of Prosthodontics, Columbia University, New York, December, 1961.

ANNOUNCEMENTS

Reprints of the second edition of the *Glossary of Prosthodontic Terms* are now available. Prices: 1 to 20 copies, fifty cents each; 20 to 49 copies, forty cents each; 50 to 99 copies, thirty-five cents each; 100 or more copies, twenty-five cents each. Orders for less than 100 will be mailed prepaid; orders for 100 or more will be sent shipping charges collect. Cash, check, money order, or institution purchase order *must* accompany the order for reprints. Orders will not be filled otherwise. Address: Glossary Reprints, 3939 Old Brownsboro Road, Louisville 7, Ky.

Reprints of Reports Nos. 1 and 2, "Principles, Concepts and Practices in Prosthodontics," may be obtained by writing Dr. W. Les Warburton, Secretary-Treasurer, Academy of Denture Prosthetics, 807 Medical Arts Bldg., Salt Lake City 11, Utah. The price is twenty-five cents for both with 20 per cent discount allowed on orders of 20 or more. Cash, check, or purchase order *must* accompany the order.

Up to date information on amalgam, burs, mercury, impression compounds, silicate cements, acrylic resins, casting alloys, and other commonly used dental materials is now available in the current edition of *ADA Specifications for Dental Materials.*

The booklet, prepared by the American Dental Association Research Division, National Bureau of Standards, includes the latest revised brand name list of certified dental materials. Information on *why* a dentist should use a certified material and how material is tested to meet American Dental Association specifications is also included in the 84 page booklet.

Copies of *ADA Specifications for Dental Materials* are available at $2.25 each from the Order Department, Desk 614, American Dental Association, 222 East Superior St., Chicago 11, Ill.

MOUTH PROTECTION FOR ATHLETES

A major occupational hazard of contact sports—loss of teeth and other injuries to the mouth—could be all but eliminated if athletes wore mouth protectors.

That is the major conclusion in a recent report issued by a joint committee on mouth protectors set up by the American Dental Association and the American Association for Health, Physical Education and Recreation.

The joint committee said it recognizes that football injuries in and around the oral cavity come to mind first, but suggested that mouth protection can be equally important in several other sports.

The committee cited hockey, basketball, wrestling, lacrosse, and soccer as involving particular need for protection. The group also noted that women's field hockey results in a considerable number of injuries.

Surveys were cited by the committee which show that injuries in and around the mouth comprise 50 per cent of football injuries. "Nearly all" of these injuries could be prevented if players wore mouth protectors, the group declared.

In line with this conclusion, the policy-making House of Delegates of the American Dental Association has urged that the wearing of properly fitted, individually fabricated mouth protectors be made mandatory for football players as well as participants in other contact sports.

Meanwhile, the National Alliance Football Rules Committee has adopted a rule making mandatory the wearing of mouth protectors by all boys participating in football. The rule becomes effective for the 1962 season.

The action applies to all members of high schools and colleges of the National Federation of State High School Athletic Associations, the Junior College Athletic Association, and the National Association of Intercollegiate Athletics.

While several types of mouth protectors are available, the joint committee recommended the custom-made. individually fabricated protector as the most satisfactory, because "it fits well, is comfortable, and does not interfere with breathing and speaking."

It is possible, the committee said, to make an inexpensive mouth protector quickly, easily, and with the desired characteristics by using self-curing latex with a rayon flock.

The protector is fabricated over a cast of the mouth of the individual player made from a dentist's impression. In many high schools and colleges where this type of protector is used, impressions have been made by volunteer dentists and the protectors fabricated by members of team booster organizations.

To implement the decision of its House of Delegates, the American Dental Association envisions a nationwide program by dental societies or individual dentists cooperating with schools in providing protectors for athletes.

While much progress has been achieved in making football and other sports safer, the committee cited a lag in adoption of safety measures that prevent injuries to teeth and mouth.

It pointed out that face guards are worn almost universally by football players, primarily for nose and cheek protection, but emphasized that the guards prevent only about 50 per cent of teeth and mouth injuries. They do not protect against blows under the chin.

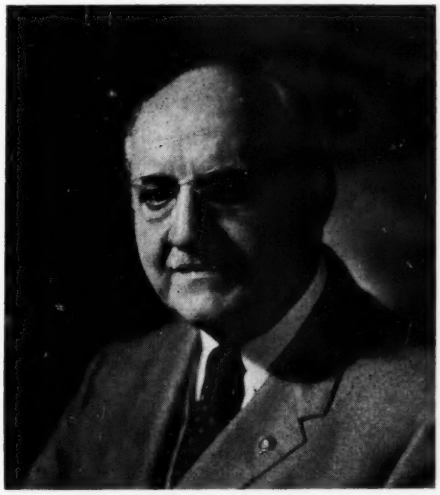
The committee reported surveys that show that mouth injuries also are caused by face guards passing each other in face to face contact. It said mouth protectors should be worn along with face guards.

There already is wide acceptance and use of mouth protectors by high schools, colleges, and universities. The committee concluded that custom-made protectors have won greatest player acceptance because they have desirable characteristics.

NATIONAL DENTAL LABORATORY WEEK

National Dental Laboratory week will be observed from Sept. 23 to 30, 1961. This week will be celebrated as part of the Tenth Anniversary of the National Association of Dental Laboratories, which is being observed this year, and will mark the "coming of age" of the ethical dental laboratories of the United States. The National Dental Laboratory week will come just before the Annual Meeting of the NADL in Chicago, Oct. 3 to 7, 1961, at which the announcement of the new dental laboratory accreditation program being developed with the American Dental Association is expected to be presented.

In the 10 years of its history, the National Association of Dental Laboratories has been building closer liaison with the profession of dentistry in its service to the dental prescription or authorization, and this year is hoped to mark the culmination of a great deal of work, planning, and development which has included, in cosponsorship with the American Dental Association, the national program of certification for dental laboratory technicians.



DOCTOR TYLMAN RETIRES

Dr. Stanley D. Tylman, Professor and Head of the Department of Fixed Partial Prosthodontics at the University of Illinois, College of Dentistry, will retire from his teaching position at the end of this academic year.

His colleagues on the faculty, in the alumni association, and in the dental profession gave a dinner in his honor to pay personal tribute to Dr. Tylman for his many contributions to dental education and science. One of these important contributions has been his service as an Associate Editor of THE JOURNAL OF PROSTHETIC DENTISTRY.

FUND FOR DENTAL EDUCATION

Dr. Maynard K. Hine, president of the Fund for Dental Education, has announced receipt of a contribution of $50,000 from the American Dental Association to support the program of the Fund for Dental Education.

Upon receipt of this gift, the Fund distributed $25,000 to the American Association of Dental Schools in accordance with the provisions of the gift. This substantial investment to advance dental education is the second such contribution made by the ADA, which invested $50,000 in the program of the Fund in 1959, he reported. It is hoped that the example set by the American Dental Association will inspire state dental societies to appoint fund raising committees to work with the Fund for Dental Education to increase giving by dentists to advance dental education, Dr. Hine said.

President Henry M. Thornton of the American Dental Trade Association has reported to Dr. Maynard K. Hine, President of the Fund for Dental Education, that the 1960 totals on the campaign conducted by the American Dental Trade Association to aid the program of the Fund for Dental Education has reached $125,971.30 and far exceeded the campaign goal of $100,000. The American Dental Trade Association is planning to conduct its second campaign for the Fund in 1961.

Readers of THE JOURNAL OF PROSTHETIC DENTISTRY are invited to present lectures, projected conferences, table clinics, and demonstrations on any aspect of the field of dentistry before the Federación Odontologica de Centro América y Panamá, Jan. 21 through 26, 1962, in Panama.

For further information write to Dr. Alfredo H. Berguido, Apartado 4115, Panamá, República de Panamá.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, offers opportunities for graduate study in oral surgery, orthodontics, prosthetics, endodontics, and oral pathology. These courses are of 1 or 2 academic years' duration. For further information write to Department of Stomatology, Boston University, School of Medicine, 80 East Concord St., Boston 18, Mass.

FELLOWSHIPS

Loyola University, Chicago College of Dental Surgery, is offering a research and teacher training program in oral biology. This is under a teacher training grant from the National Institutes of Health. It is designed for candidates who desire a teacher's career in basic sciences or in clinical subjects. The stipends are up to $5,000 per year, and the program can lead to an advanced degree.

For further information and application write to Dr. Harry Sicher, Director, Loyola University, Chicago College of Dental Surgery, 1757 West Harrison St., Chicago 12, Ill.

Tufts University, School of Dental Medicine, announces two research fellowships in periodontology beginning September, 1961; also, three full-time graduate courses in periodontology.

For further information and application write to Dr. Irving Glickman, Periodontology, Tufts University, School of Dental Medicine, 136 Harrison Ave., Boston 11, Mass.

POSTGRADUATE COURSES

The University of Alabama, School of Dentistry, announces the following refresher course:

Surgical Anatomy of the Head and Neck: Dr. Harry Sicher, May 22 to 24, 1961.

For further information and application write to the Director, Refresher Course Program, University of Alabama, School of Dentistry, 1919 Seventh Ave. S., Birmingham, Ala.

The Albert Einstein College of Medicine, Department of Dentistry, will sponsor postgraduate courses in anesthesiology, endodontics, oral pathology, oral surgery, periodontics, and prosthetics during the spring of 1961. These courses are designed to be integrated into the general dental practice. Lecture sessions will be held at the Albert Einstein College of Medicine and the clinical demonstrations at the Dental Clinic, Jacobi Hospital.

For further information and application write to the Director, Postgraduate Dental Division, Albert Einstein College of Medicine, Eastchester Rd. and Morris Park Ave., Bronx 61, N. Y.

Boston University, School of Medicine, Division of Graduate Studies, Department of Stomatology, announces the following postgraduate courses:

Full Mouth Reconstruction: Dr. Leo Talkov, Dr. David J. Baraban, Dr. Henry M. Goldman, Dr. Bernard S. Chaikin, Dr. Gerald M. Kramer, and Dr. J. David Kohn, May 15 to 19, 1961.

Pedodontics for the General Practitioner: Dr. Harold Berk, May 19 and 20, 1961.

Surgical Procedures in Periodontal Therapy: Dr. Lewis Fox and associates, May 22 to 26, 1961.

For further information write to Director of Postgraduate Studies, Department of Stomatology, Massachusetts Memorial Hospitals, 750 Harrison Ave., Boston 18, Mass.

New York University, College of Dentistry, announces the following postgraduate course:

Workshop in Practice Management, Doctor-Patient Relations, Motivation of Patients: J. Lewis Blass and associates, June 19 to 23, 1961.

For further information and application write to Director, Postgraduate Division, New York University, College of Dentistry, 421 First Ave., New York 10, N. Y.

New York University announces courses for 1961-1962 to be given in fixed partial prosthesis and in complete oral rehabilitation. Both courses involve practical chair work, lectures, and demonstrations. "Fixed Partial Prosthesis" utilizes elastic impression materials. It will be given on Friday afternoon for 16 weeks beginning January, 1962, by Prof. Edward G. Kaufman.

"Complete Oral Rehabilitation" will be given every Friday for 32 weeks beginning October, 1961. The course covers full mouth treatment utilizing axis registrations and detailed occlusal study. Enrollment is limited, and acceptance is made only after personal interview. Instructors are Prof. David H. Coelho, Prof. Eugene A. Rothschild, and Prof. Albert Zola.

For further information and application write to Director, Postgraduate Division, New York University, College of Dentistry, 421 First Ave., New York 10, N. Y.

The University of North Carolina, School of Dentistry, announces the following postgraduate courses:

Clinical Periodontia and Oral Pathology, June 6 to 10, 1961.

Design and Case Analysis for Clasp Partial Dentures, June 15 to 17, 1961.

Dentistry for Children I, July 10 to 14, 1961.

Dentistry for Children II, July 17 to 21, 1961.

Dentistry for Children III, July 24 to 28, 1961.

For further information and application write to Office of Postgraduate Dental Instruction, University of North Carolina, School of Dentistry, P. O. Box 750, Chapel Hill, N. C.

Northwestern University Dental School announces the following postgraduate courses:

Recent Advances in Amalgam Techniques, May 15 and 16, 1961.

Conference for Teachers of Pedodontics, June 5 and 6, 1961.

For further information and application write to Northwestern University Dental School, 311 East Chicago Ave., Chicago 11, Ill.

The Ohio State University, College of Dentistry, announces the following postgraduate courses:

General Anesthesia: Dr. Morgan Allison, May 15 to 19, 1961.

Dental Drugs in Action: Dr. W. Russell Kampfer, May 19 and 20, 1961.

Oral Surgery: Dr. Morgan Allison, May 22 to 26, 1961.

For further information and application write to the Ohio State University, College of Dentistry, 305 West Twelfth Ave., Columbus 10, Ohio.

The University of Pennsylvania, School of Dentistry, announces the following postgraduate course:

Biologic Aspects of Endodontics: Dr. Samuel Seltzer and Dr. I. B. Bender, May 22 to 26, 1961.

For further information and application write to Director of Postgraduate Courses, University of Pennsylvania, School of Dentistry, 4001 Spruce St., Philadelphia 4, Pa.

Tufts University School of Dental Medicine announces the following postgraduate courses:

The Diagnosis and Treatment of Pain and Other Symptoms Arising From Temporomandibular Joint Disturbances, May 23 and 24, 1961.

Full Denture Prosthesis, June 5 to 9, 1961.

A Special Participation Course in Periodontology, Oct. 9 to 13, 1961.

For further information and application write to Director of Graduate and Postgraduate Studies, Tufts University School of Dental Medicine, 136 Harrison Ave., Boston, Mass.

West Virginia University, School of Dentistry, announces the following postgraduate courses:

Cephalometry: Dr. V. Sassouni and Dr. W. M. Krogman, May 22 to 24, 1961.

Inlay Restorations: Dr. R. E. Sausen, Fridays, June 16, 23, and 30, 1961.

For further information and application write to Kenneth V. Randolph, Dean, West Virginia University, School of Dentistry, Morgantown, W. Va.

Yeshiva University, Albert Einstein College of Medicine, Department of Dentistry, announces the following postgraduate courses:

Anesthesiology: Dr. Stanley R. Spiro and associates, June 9, 1961.

Periodontics: Dr. Irving Yudkoff, Dr. Marvin N. Okun, and associates, Oct. 30 to Nov. 3, 1961.

Advanced Oral Pathology: Dr. Ernest Baden and associates, 3 consecutive days during December, 1961.

For further information and application write to Director, Postgraduate Dental Division, Yeshiva University, Albert Einstein College of Medicine, Eastchester Rd. and Morris Park Ave., Bronx 61, N. Y.

HOSPITAL INTERNSHIP AND RESIDENCY PROGRAMS

The Veterans Administration Hospital, Iowa City, in affiliation with the State University of Iowa, College of Dentistry, announces that two rotating dental internships and one residency in prosthetics will be available for 1 year beginning July 1, 1961.

For further information and application write to the Chief, Dental Service, Veterans Administration Hospital, Iowa City, Iowa.

The Veterans Administration Hospital, Philadelphia, is now accepting applications for the 1 year rotating internships available July 1, 1961. The program is given in cooperation with the affiliated Dental and Medical Schools. A Certificate of Internship is awarded by the Hospital.

For further information and application write to Dr. S. L. Orlean, Chief, Dental Service, Veterans Administration Hospital, Philadelphia 4, Pa.

The Veterans Administration Medical Teaching Group Hospital of Memphis announces that two rotating dental internships and one residency in prosthodontics will be available for the year beginning July, 1961.

For further information and application write to Dr. Robert T. Holt, Chief, Dental Service, Veterans Administration Medical Teaching Group Hospital, Memphis, Tenn.

Those interested in a 2 year residency program in prosthodontics at the Veterans Administration Center, Wood, Wis., beginning July 1, 1961, should apply immediately. The residency program is affiliated with Marquette University, School of Dentistry.

For further information and application write to the Manager, Wood Veterans Administration Center, Milwaukee, Wis.

The Dental and Oral Surgery Service of the Mount Sinai Hospital in New York City announces that it is accepting applications for internships and residency for the calendar year beginning July, 1961.

For further information and application write to Dr. Max Fuchs, Assistant Director, The Mount Sinai Hospital, 11 East 100th St., New York 29, N. Y.

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